BOOK OF ABSTRACTS

The 9th International Symposium on
the Natural Radiation Environment (NRE-IX)
September 22 - 26, 2014, HIROSAKI, JAPAN

HIROSAKI UNIVERSITY

IAEA
International Atomic Energy Agency

NRE-IX

The 9th International Symposium on the Natural Radiation Environment

22 - 26 September, 2014,
HIROSAKI, JAPAN

Chair
Shinji Tokonami

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Invitation to the NRE-IX

The scientific programme of the NRE9 will cover all aspects of natural radiation exposure including radon and thoron, any issues related to legislation problems and epidemiological studies. In addition, special session about Fukushima nuclear accident is planned. The symposium will include invited, oral and poster sessions.

The NRE9 Conference will be held in Hirosaki City, north part of Japan and the Hirosaki University is a host.

Hirosaki is surrounded by a splendid landscape of mountains: to the east is the Hakkoda Mountain Range, to the west is Mt. Iwaki, and to the south is "Shirakami-Sanchi," a mountainous expanse of virgin forest, which is a World Natural Heritage Site. Due to these geographical conditions, the summers in Hirosaki are short and the winters are long, and the city is blessed with four distinct seasons.

Shinji Tokonami, Ph.D. & Professor
General Chair of NRE-IX,

床次眞司

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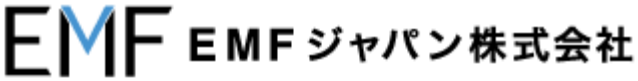
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ABSTRACTS

KEYNOTES

CHARACTERISTICS AND EFFECTS OF NATURAL RADIATION

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Since life first appeared on the planet it has, in all its subsequent evolved forms including human, been exposed to natural radiation in the environment both from terrestrial and extra-terrestrial sources. As an environmental mutagen ionizing natural radiation may have played a not-insignificant role in the evolution of early life forms on Earth. It has been estimated by UNSCEAR that at the present time exposure to natural radiation globally results in an annual average individual effective dose of about 2.4 mSv which is about 80% of the total dose from all sources. The three most important components of natural radiation exposure are due to cosmic radiation, terrestrial radioactivity and indoor radon. Each of these components exhibit both geographical and temporal variability with indoor radon exposure being the most variable and the largest contributor to dose for most people.

In this account an overview is given of the characteristics of the main components of the natural radiation environment and some of their effects on humans. In the case of cosmic radiation these range from radiation doses to astronauts and aircrew to the controversial topic of its possible effect on climate change. In the case of terrestrial natural radiation accounts are given of a number of human exposure scenarios.

THE HISTORY, DEVELOPMENT AND THE PRESENT STATUS OF THE RADON PROGRAM IN THE UNITED STATES OF AMERICA

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The US Radon measurement program began in the late 1950's by the US Public Health Service in Colorado, New Mexico and Utah during the uranium frenzy. After the 1967 Congressional Hearings on the working conditions in uranium mines, the US Atomic Energy Commission (AEC) was asked to conduct studies in active uranium mines to assess the exposure of the miners on the Colorado Plateau and in New Mexico. From 1967-1972 the Health and Safety Laboratory (HASL) of the US AEC in New York investigated more than twenty uranium mines for radon and radon decay product concentrations and particle size in four large uranium mines in New Mexico. In 1970, the US Environmental Protection Agency (EPA) was established and took over some of the AEC radon measurement activities. Between 1975-1978, the Environmental Measurements Laboratory (EML) of the US Department of Energy (DOE) conducted the first detailed indoor radon survey in the US. Later in 1984, the very high concentrations of radon in Pennsylvania homes set the wheels in motion and gave birth to the US Radon Industry. The US EPA expanded its involvement in radon activities and assumed an active role and established the National Radon Proficiency Program (NRPP) to evaluate the effectiveness of radon measurement and mitigation methods. In 1998, due to limited resources EPA privatized the radon program. In this paper I will present an update on radon health effects, the incidence rate of lung cancer in the US and the number of radon measurements made from 1988-2013 using short-term test methods. More than 21 million measurements were made in the last 25 years and as a result more than 1.1 million homes were mitigated successfully. Probably <1% of the radon measurements in the US are made with long-term testing. The current number of homes above the US action level of 148 Bq/m3 (4 pCi/L) may be > 8.5 million because more than 40 million homes were added to the home inventory. This paper will discuss the current instruments and methods used to measure radon in the US and what is the effectiveness of radon resistant new construction, the current state of mitigation standards and the proposed testing protocols in schools and large buildings.

Key words: radon, methods, mitigation, radon resistant construction, case control studies

THE IMPACT OF THE SPACE RADIATION ENVIRONMENT ON HUMAN SPACE EXPLORATION

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One of the major challenges to long duration human space missions such as manned missions to Mars or near-Earth asteroids or the establishment of a permanent human base on the Moon is the risk to space crew health and safety posed by exposure to the space radiation environment. The space radiation environment is highly complex, consisting of charged particles from beyond the solar system (i.e. galactic cosmic rays), charged particles emitted by the sun (i.e. solar particle events) and, in Earth orbit, trapped electrons and protons. This incident radiation field is then modified as it propagates through the mass and into the habitable volume of a spacecraft or surface habitat. In this presentation, we review the current status of radiation protection and dosimetry of space crews, including results from a number of new space radiation dosimeters. We also consider the role of passive shielding in reducing total absorbed dose and dose equivalent received by space crews, especially the contribution from high energy (greater than ~1 GeV) galactic cosmic ray protons.

ACHIEVEMENTS AND LIMITATIONS OF DYNAMICAL MODELING OF ENVIRONMENTAL RADIOACTIVITY BEHAVIOR

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Dynamical modeling of behavior of environmental radioactivity, whether natural or anthropogenic, has long been considered as a useful and powerful, or at least promising approach to understand processes affecting the behavior and to assess and predict its environment and radiological consequences. This notion is supported by many examples of models successfully describing key processes of environmental transfer of radionuclides, such as ones describing the radon exhalation from the ground surface and atmospheric transport models. An idea of combining both of the source and transport models seems promising in better depicting the global or regional distribution of radon exhalation rate. It should, however, be pointed out that there is no single global radon exhalation map that can satisfactorily reproduce the observed atmospheric concentration if used as an input to an atmospheric transport model.

Atmospheric transport models for radionuclides have been improved drastically in the last two decades with the help of progresses in our understanding in the atmospheric science. The improved models can realistically reproduce concentration changes of atmospheric radioactivity such as radon and its progenies, although there still remains substantial uncertainty in the calculated atmospheric concentrations. The models were, in most cases, successfully applied to the nuclear accident in Japan with practical purposes of predicting or retrospectively analyzing the consequence of the atmospheric release of radionuclides. However, it should be pointed out again that there were also limitations in the usefulness and reliability of the dynamical models not only from the scientific point of view of the model performance but also from point view of the non-scientist end users of the information provided by the models.

EPIDEMIOLOGICAL STUDIES ON CANCER RISK ASSOCIATED WITH LOW DOSE AND DOSE RATE RADIATION EXPOSURE

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Whether chronic exposure has an cancer risk per dose different from that of acute exposure is a topic of debate. This paper discusses the effect of dose rate on the strength of relationship between cancer risk and external exposure to low-LET (Linear Energy Transfer) ionizing radiation (such as X-rays and gamma rays), by reviewing important epidemiological studies. The study of atomic-bomb survivors, who had acute exposure mainly to low-LET ionizing radiation, has shown that the excess relative risk per gray (ERR/Gy) of leukemia increases in a linear-quadratic manner with an increase of radiation dose. The estimate of ERR/Gy for medium-high dose ranges was shown to be approximately two-fold larger than that for a low-dose range in the atomic-bomb survivor study. However, it is difficult to evaluate the dose-rate effect on leukemia risk since the estimates of ERR/Gy obtained from the studies of low-dose-rate exposure have uncertainties and wide confidence intervals. In the case of solid cancer (or all cancers excluding leukemia), the study of atomic-bomb survivorsits has shown a linear dose-response relationship. Interestingly, the cancer incidence study of residents in high natural background radiation areas of Karunagappally Taluk in Kerala State, India suggests that the ERR per dose for solid cancer after chronic radiation exposure is significantly lower than that associated with acute exposure such as that experienced by atomic-bomb survivors. A similar study in the high background radiation area of Yangjiang in Guangdon Province, China supports this conclusion.

INTERNATIONAL STANDARDS AND RADIATION MEASUREMENT

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International standards respond to a need in the market expressed as a request from industry or other stakeholders such as consumer groups. Typically, an industry sector, such as the one dealing with nuclear energy, or a group, such as heads of radioactivity testing laboratories, communicates the need for a standard to its national standardization organization which then contacts the international body in charge of publishing international standards.

Among the international bodies that collaborate to publish standards on testing methods, the main organizations are the Bureau International des Poids et Mesures (BIPM), the International Federation of Clinical Chemistry and Laboratory Medicine (IFCC), the International Organization of Legal Metrology (OIML), the International Laboratory Accreditation Cooperation (ILAC), the International Union for Pure and Applied Chemistry (IUPAC), the International Union for Pure and Applied Physics (IUPAP), the International Commission on Radiation Units and Measurements (ICRU), the International Electrotechnical Commission (IEC), and the International Standardization Organization (ISO). The three last bodies deal more specifically with radioactivity measurement standards.

Once the need for an international standard has been established, it is developed by a panel of experts nominated from all over the world, usually within a technical committee (TC) of one of these international bodies. The experts come from the relevant industry, but also from consumer associations, academia, NGOs and government as in the case of ISO. This approach ensures that international standards are drafted through a multi-stakeholder process.

The experts meet to discuss and negotiate a draft standard, including its scope, key definitions and all the technical content. As soon as a draft has been developed it is shared with the members who are asked to comment and vote on it. This consensus-based approach ensures that comments from stakeholders are taken into account. Once consensus is reached on the draft it becomes an international standard, if not, it goes back to the technical committee for further reviews and improvements.

IEC/TC 45 Nuclear Instrumentation prepares international standards relating to electrical and electronic equipment and systems for instrumentation specific to nuclear applications and ISO/TC 85 Nuclear Energy, Nuclear Technologies, and Radiological Protection is in charge of standardization in the field of peaceful applications of nuclear energy, nuclear technologies and in the field of the protection of individuals and the environment from all sources of ionising radiation. They cooperate to ensure that their standards fit together seamlessly and complement each other.These two TCs have published over a hundred international standards available to those doing radioactivity tests needed in dosimetry, radioprotection, etc.

The presentation will cover the key principles in IEC and ISO international standard development and will review those standards of relevance in radioprotection, including food and environmental monitoring.

SYSTEMATIC APPROACH TO CHARACTERIZATION OF NORM IN THAILAND

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The aim of this article is to provide information on the systematic approach that has been developed for the measurement of natural radiation exposure and the characterization, in terms of occurrence and distribution, of naturally occurring radioactive materials (NORM) in various industrial processes as well as the produced waste from the mineral industries in Thailand. The approach can be adapted for various types of study areas. The importance of collaboration among research institutions will be discussed. Some developments include twenty five documents to carry out the work; the redesign of the field equipment, such as the gamma survey meter, for convenience access to conduct measurement in various study areas; the method to collect and analyze radon gas from a natural gas pipeline; and the manganese dioxide fiber to adsorb radium on-site for laboratory analysis. The NORM project in Thailand has been carried out for more than 10 years to support the development of NORM regulation in Thailand. In our previous studies, international standards for action levels have been adopted for safety purpose.

COMPARATIVE STUDY OF VARIOUS TECHNIQUES FOR ENVIRONMENTAL RADON, THORON AND PROGENY MEASUREMENTS

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Long term average concentrations of radon, thoron and progeny were measured in normal (Garhwal Himalaya, Uttarakhand) and high background radiation (Chhatrapur, Orissa) areas in India using different techniques. In Garhwal Himalaya, measurements were carried out in modern houses (cemented), traditional houses (made of local stone and soil) and wooden houses. In Chhatrapur, Orissa area, cemented, bricks and mud houses were selected for the measurements. Radon, thoron and progeny concentrations were measured using pin–holes dosimeter, Raduet, deposition based CR-39 and DTPS/DRPS detector system. All these techniques were used at a same time inside an individual dwelling. The pinhole dosimeter with LR-115 track detector was used for the measurements of radon and thoron concentrations in the dwellings. Another CR-39 detector based technique (Raduet) was also used for measurements of radon and thoron concentrations in the same house for the comparison of the results. Direct thoron progeny sensors (DTPS) and direct radon progeny sensors (DRPS) developed by Bhabha Atomic Research Centre, Mumbai were used for the measurements of time-integrated radon and thoron progeny concentrations. For comparison of the results, the deposition based CR-39 technique was used for the measurements of the concentration of thoron progeny in the same dwellings. Radon concentration was recorded higher than thoron concentration in Garhwal Homes while thoron concentration was found relatively higher in the houses of Chhatarpur area. The values measured with CR-39 detector based technique were found comparable with the values measured with LR-115 detector based technique. The comparisons of results using various techniques and their usefulness in radiation measurements are discussed in details.

RADIATION PROTECTION IN POLISH COAL MINES - SYSTEM OF MONITORING AND CONTROL OF THE HAZARD

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The radiation risk due to the exposure to natural radionuclides, especially to short-lived radon progeny, is a component of the radiation hazard, common in the natural environment and working environment of human beings. Under specific circumstances, for example as a result of working in confined space with low ventilation rate (cellars, underground galleries, tunnels, mines), the role of that particular hazard may be much bigger. The radiation hazard in Polish mines is treated as the one of the natural hazards in underground mines, like methane hazard, tremor hazard etc. The investigations of the natural radioactivity in underground mines in Poland have been started in early 1970's. Firstly, efforts were focused on solving the problem of occurrence of radium-bearing waters and sediments with enhanced radioactivity in underground galleries. Later, in early 1980's the importance of the exposure to radon progeny have been discovered.

During several years of extended investigations main sources of radiation hazard in underground mines have been recognised. Methods of measurement have been developed, suitable instrumentation for underground application, were designed and system of radiological protection has been implemented in all underground mines in Poland.

Due to being in force regulatory acts - Geological and Mining Law, Decree of the President of State Mining Authority and Decree of the Ministry of Economy – the monitoring and prevention against natural radiation is obligatory in all Polish underground mines since 1989. This duty is strictly supervised by local offices of State Mining Authority in co-operation with other governmental agencies. Monitoring and mitigation measures are obligatory not only for active mines but also for mines, excluded from the exploitation, and used for other purposes as museums, balneotherapy spas etc. Such a solution is rather unique in non-uranium mining, although during 25 years of its use in mining industry in Poland, this system has been updated and changed several times to be in agreement with current radiation protection regulations.

MODULATION OF NF-KB IN RESCUED IRRADIATED CELLS

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Rescue effect" occurs when bystander cells/organisms on receiving the bystander signals send feedback signals to the irradiated cells/organisms to mitigate the biological effects on the irradiated cells/organisms.

We studied the dependence of the rescue effect on the relative abundance of the bystander cells, by employing the HeLa and NIH-3T3 cells under the confluence condition. We employed three irradiation patterns, namely, (A) 2.5%, (B) 75% and (C) 100% of a cell population were irradiated with alpha-particle doses (either 5 or 20 cGy). The cells were fixed at 2 or 12 h after irradiation and the immunofluorescent intensity of NF-kB in the cytoplasm of cells were quantified.

For HeLa cells, the NF-kB intensity at 2 h for 5 and 20 cGy were increased by ~15% and 35% compared to the non-irradiated control, respectively, for all irradiation patterns. The NF-kB intensity at 12 h for 20 cGy was increased by 80% for all irradiation patterns. The NF-kB intensity at 12 h for 5 cGy was increased by 65% for (A), and increased by ~45% for (B) and (C).

For NIH-3T3 cells, the NF-kB intensity at 2 h for 5 cGy were increased by 46%, 26% and 14% compared to non-irradiated control, respectively, for (A), (B) and (C). The NF-□B intensity at 12 h for 5 cGy was reduced to the basal level of non-irradiated control for all irradiation patterns. The NF-kB intensity at 2 h for 20 cGy was similar for all irradiation patterns of, and were all increased by ~50% compared to non-irradiated control. The NF-kB intensity at 12 h for 20 cGy was increased by 27% for (A), and increased by ~15% for (B) and (C).

Our results showed stronger rescue effect for larger relative abundance of bystander cells, but the relationship is dose dependent and cell-line dependent.

AN OVERVIEW OF RADON RESEARCH IN CANADA

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Recent scientific studies have conclusively linked an increased risk of developing lung cancer to levels of radon found in homes. These studies prompted the Canadian federal government to collaborate with provincial and territorial governments to review the Canadian radon guideline. Based on new scientific information and a broad public consultation, the guideline was lowered from 800 to 200 Bq m^{-3} in June 2007. In addition to residential homes, the new guideline also applies to public buildings with a high occupancy rate by members of the public, and workplace exposure limits were harmonised with this new guideline as shown in the newly revised Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials. The new radon guideline recommends techniques be employed in new home construction to minimise radon entry and facilitate post-construction radon reduction, should this subsequently prove necessary. The revised radon guideline provides advice that is more broadly applicable and more protective than the previous guideline.

To support the implementation of the revised guideline, a National Radon Program (NRP) was developed. The NRP consists of five components: (i) establishment of a National Radon Laboratory (NRL), (ii) radon testing projects, (iii) radon database and mapping, (iv) radon research and (v) education and public awareness. Some of the achievements accomplished in the past seven years, and on-going activities in the radon research component of the NRP are highlighted here.

FROM CELLULAR DOSES TO AVERAGE LUNG DOSES

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Energy deposition by radon progeny alpha particles in individual bronchial cell nuclei, resulting in oncogenic Energy deposition by radon progeny alpha particles in individual bronchial cell nuclei, resulting in oncogenic transformation, is the necessary initiating radiobiological effect for the induction of bronchial carcinomas. Sensitive basal and secretory cell nuclei receive a wide range of doses in human bronchial airways. Thus the question arises of how to reduce these cellular dose distributions to a single value for the average lung dose to be related to lung cancer risk. It is current practice to give each cellular dose the same statistical weight, which is based on the assumption of dose-effect linearity. However, alternative weighting schemes have been proposed and will be discussed here. Within a given bronchial airway, cellular doses decrease nearly linearly with depth in bronchial epithelium. An average dose for a given bronchial airway can then be obtained by giving the cellular dose at each depth interval the same statistical weight. Alternatively cellular doses may be weighted by the depth distributions of basal and secretory cells in each generation. The asymmetry and the variability of bronchial airway dimensions, affecting deposition, clearance and epithelial thickness, produce a wide distribution of average bronchial airway doses within a given airway generation, which can be approximated by lognormal distributions. Averaging over all bronchial airways in the bronchial and bronchiolar regions with equal statistical weight yields then average bronchial and bronchiolar doses. Alternatively, airway generation doses may be weighted by the relative frequencies of target cells or by the total number of epithelial cells in each airway generation. The application of regional apportionment factors to bronchial, bronchiolar and alveolar doses, either assuming equal weight or based on the local distribution of lung tumors, finally leads to an average lung dose. Additional weighting scenarios may be introduced by assuming different radiosensitivities for basal and secretory cells and by considering highly localized doses at airway branching sites relative to cylindrical airway portions. In case of smokers, the bronchial deposition pattern of inhaled cigarette smoke particles, acting as a promotion factor in the carcinogenic process, may serve as another weighting factor. Considering all these different weighting schemes for the averaging procedures, dose-exposure conversion coefficients may vary by a factor of about 3. This raises the question, which physically and biologically reasonable weighting procedures are consistent with the currently available pathological and epidemiological evidence.

REUSING OF HUNGARIAN (NORM ORIGIN) INDUSTRIAL BY-PRODUCTS

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The depletion of raw materials demands new innovative solutions to ensure the sustainability in future for production sector. Several industrial by-products originated in huge amount can be used as additive material in numerous technologies. In Hungary several reuse possibilities have been surveyed related to by-products, such as red mud (alumina industry), bottom and fly ash (coal combustion), manganese clay (Manganese ore refining).

To reduce environmental impact and provide economical reuse options numerous samples have been taken and the possible reuse options were surveyed. In some cases to investigate the practicability potential pilot-samples were prepared mainly from clay based mixed additives (red mud and manganese clay) to fabricate different indoor and outdoor building materials and also potteries.

In so many cases certain components of the raw materials enhanced in by-products can have effect on environment and human health as well. In addition to the toxic components the natural radionuclide content can contribute to the risk caused by them. In order to avoid elevated risk overall investigation procedure is required focus on the mobility of toxic components (leaching properties) and radiation exposure (gamma dose rate and radon/thoron exhalation).

In this study the performed investigation procedure and the effect of heat treatment are presented necessary to characterize the goods prepared from reused industrial by-products.

INTERNATIONAL STANDARDS FOR PROTECTION AGAINST EXPOSURE DUE TO THE NATURAL SOURCES OF RADIATION

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The requirements relating to protection of the public against exposure the natural sources of radiation were strengthened during the revision of the International Basic Safety Standards that completed in 2011, and published as IAEA Safety Requirements publication Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards (GSR Part 3) [1]. The natural sources of radiation include: existing residues in the environment, radon, cosmic rays and radionuclides in commodities such as building materials and drinking water. The requirements include the requirements for governments to ensure that existing exposure situations that have been identified are evaluated to determine which occupational and public health exposures are concern from the point of view of radiation protection. Governments are required to assign responsibilities for protection and safety, and to establish appropriate reference levels.

The IAEA has also developed a Safety Guide that provides guidance on applying the requirements in GSR Part 3 [2] in relation to control of natural sources of radiation indoors. This Safety Guide provides guidance in relation to exposure due to radon and to radionuclides in building materials. The Safety Guide includes guidance on the development of national radon actions plans, where appropriate, and on the development of a process for the control of natural radionuclides in building materials, providing an example of an activity concentration index a screening tool for identifying building materials that might need to be subject to restriction. This paper will summarise the requirements and guidance in the IAEA safety Standards for the control of exposure to natural sources of radiation.

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Safety Standards Series No. GSR Part 3 (Interim Edition), IAEA, Vienna (2011).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Protection of the public against Exposure Indoors to Natural Sources of Radiation, (in print).

A REVIEW OF DOSE ESTIMATION STUDIES CONDUCTED AFTER THE FUKUSHIMA DAIICHI NUCLEAR POWER PLANT ACCIDENT

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Since the Fukushima Daiichi Nuclear Power Plant accident began, many dose estimation studies have been done. The UNSCEAR 2013 report, published in April 2014, well summarizes the doses due to the Fukushima accident. The report estimates effective doses and thyroid doses for 1-y and 10-y children as well as adults. This paper will briefly mention the doses summarized by the UNSCEAR report. In addition, this paper will review some information including articles or official announcement not cited in the UNSCEAR report. Topics of the information were categorized as follows: (1) internal dose to the thyroid, (2) internal dose to the whole-body, and (3) external dose. Corresponding to each item, the following studies will be mentioned: (1) thyroid dose estimation by simulation and simultaneous measurement of indoor and outdoor radionuclide concentrations, (2) whole-body counting results in Fukushima Prefecture and cesium intake estimation by food analysis, and (3) Fukushima Health Management Survey and personal dosimeter measurements.

ORAL PRESENTATIONS

VEHICLE-BASED TERRESTRIAL GAMMA-RADIATION SURVEY USING 4 × 4 × 16″ NAI(TL) SCINTILLATION DETECTOR FOR JEJU ISLAND AND 30 KM RADIUS AREA AROUND THE HANBIT NUCLEAR POWER PLANT SITES IN KOREA

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Terrestrial γ-Radiation Monitoring System (TRMS) was developed as a module of the national emergency management system for radiation monitoring in Korea (SIREN; System for Identifying Radiation in Environments Nationwide). To obtain background γ-radiation map around nuclear sites, monitoring vehicles equipped with NaI detector, HPIC, GPS receiver, and etc. The vehicles move less than 60 km/h and every 10 second γ-ray NaI spectra were collected and sent into the SIREN-TRMS data server with the information of precise GPS locations and measurement times via 3G wires data communication network, automatically. To avoid overlapping of measurement between vehicle survey teams, measurement data such as surveyed routes was feedback from the SIREN-TRMS server to each vehicle survey team with real time. To obtain consistent spectra of each detector, each survey team perform in-situ energy calibration, periodically using ^{214}Bi (609.3keV), ^{40}K (1460.8 keV), ^{214}Bi (1764.5 keV), and ^{208}Tl (2614.7 keV) photo-peaks. After survey, all data was separated and sorted by administrative area and can be download from SIREN-TRMS Server to local PC as the Microsoft Excel data form for geostatical assessment. Base on the survey result of three exploration teams, contour maps of terrestrial γ-radiation for Jeju island and around Hanbit nuclear power plant sites have been completed. Nationwide terrestrial γ-radiation surveillance will be conducted continuously during next four year including around other four nuclear power plant sites in Korea.

NATURAL RADIONUCLIDES ANALYSIS IN SOIL SAMPLES OF PUROLA AREA OF GARHWAL HIMALAYA, INDIA

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Naturally Occurring Radioactive Materials are widely spread in the earth's environment, being distributed in soil, rocks, water, air, plants and even within the human body. All of these sources have contributed to the increase in the levels of environmental radioactivity and population radiation doses. This paper presents the activity level due to the presence of the 226Ra, 232Th and 40K in soil samples of Purola area in Garhwal Himalaya region. The measured activity of 226Ra, 232Th and 40K in collected soil samples of purola was found to vary from 13±10 Bq/kg to 55±10 Bq/kg with an average of 31 Bq/kg, 13±10 Bq/kg to 101±13 Bq/Kg with an average 30 Bq/kg and 150±130 Bq/kg to 1310±154 Bq/kg with an average 583 Bq/kg, respectively. The radium equivalent activity in collected soil was found to vary from 47 Bq/kg to 221 Bq/kg with an average of 115 Bq/kg. The total absorbed gamma dose rate in this area was found to vary from 22 nGy/h to 93 nGy/h with an average of 55 nGy/h. The distribution of these radionuclides in the soil of study area is discussed in details.

INDOOR EXPOSURE TO γ − RADIATION IN SOME SELECTED LOCATIONS IN IBADAN, SOUTHWESTERN NIGERIA

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Indoor exposure to gamma radiation was investigated by using LiF thermoluminescent dosimeters $(TLDs)$, which were placed within some family dwellings built with cement, mud and baked clay in various locations in Ibadan for a period of $60\ days$. The study area was divided into ten zones. A total number of $75\ TLDs$ made of LiF that gives good luminescence on heating were used to measure the indoor exposures in 75 family dwellings.

The dosimeters were first heated to $300^oC\ (573K)$ for about 16 hours in an annealing oven and then cooled at $80^0C\ (353K)$ for 17 hours. The $TLDs$ were then calibrated to read absorbed dose in microsieverts (μSv) and then packaged inside polythene sachets. Within each building, a dosimeter was hung near the wall at a height of $3m$. Routine checks were made on the dosimeters regularly. After the exposure for 60 days, the $TLDs$ were removed from within the buildings and then read using the $SOLARO\ 654\ TLD$ reader.Results show that highest absorbed dose was observed in houses built with cement while the least was observed in dwellings of mud.

Keywords : Absorbed dose, Indoor exposure, Thermoluminescent, dosimeter, Gamma radiation

POSTER PRESENTATIONS

DETERMINATION OF CS-137 AND CO-60 CONTAMINATION IN THE AREA OF LAGUNA VERDE NUCLEAR POWER PLANT-MEXICO

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The project ""Radiological Analysis of Environmental Samples in the Gulf of Mexico and the coast of Quintana Roo,"" has the objective to identify and quantify natural and anthropogenic radionuclides in environmental samples consisting of silt, sand and sea water. This paper presents the results of the analysis in these samples, which were radiologically analyzed in the multichannel system for gamma spectrometry with hyperpure germanium detector in the ""Laboratory of Radiological Analysis of Environmental Samples"", located in the Physics Department, Faculty of Sciences of the Autonomous National University of Mexico (UNAM).

The sampled points were in the coast comprising the states of Tamaulipas, Veracruz, Tabasco, Campeche, Yucatan and Quintana Roo.

This paper presents qualitative and quantitatively the concentration of the main identified natural radionuclides and also the anthropogenic radionuclides such as Cobalt-60 (Co-60) and Cesium-137 (Cs-137), the latter ones were only found in front of the Laguna Verde Nuclear Power Plant.

This project was sponsored by the ""Program for Support of Investigation and Innovation Projects"" (PAPIIT), General Direction of Support to Academic Personnel, UNAM this project lasted three years.

ABSORBED DOSE RATE IN AIR IN METROPOLITAN TOKYO BEFORE THE FUKUSHIMA DAIICHI NUCLEAR POWER PLANT ACCIDENT

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Large amounts of artificial radionuclides were released to the environment by the nuclear accident at the Fukushima Daiichi Nuclear Power Plant that occurred in March 2011. Since that time, monitoring of absorbed dose rate in air has been done continually in various locations. However, data obtained before the accident are needed to more accurately assess the effects of radionuclide contamination from the accident. The absorbed dose rate in air for all of Japan has been reported from National Institute of Radiological Sciences, Japan. But, detailed data for metropolitan Tokyo obtained before the accident are needed to assess the effects there. A car-borne survey of the absorbed dose rate in air in the metropolitan Tokyo was carried out during August 25 to September 2, 2003. A 2”× 2” NaI(Tl) scintillation survey meter was used for dose rate measurement, and the gamma-ray counts were measured every minute. The absorbed dose rate in air outside the car at 1 m above the ground was calculated by multiplying the coefficient for the shielding effect of the car body and the dose-rate conversion factor with the count rate inside the car. The shielding coefficient and dose-rate conversion factor were 1.60 and 0.7 Sv/Gy, respectively. The average absorbed dose rate in air in the metropolitan Tokyo area was 49 ± 6 nGy/h. The absorbed dose rate in air in western Tokyo was higher compared to central Tokyo. Here, if the absorbed dose rate in indoor air is equivalent to that of outdoor air, the annual effective dose would be calculated as 0.3 mSv/y.

NATURAL VARIATION OF DOSE RATE IN AIR AT IZU-OSHIMA ISLAND AFTER THE FUKUSHIMA DAIICHI NUCLEAR POWER PLANT ACCIDENT

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The Fukushima Daiich Nuclear disaster caused significant damage to the environment. We measured natural variation of dose rate in air at Izu-Oshima Island from 2011 to 2013 to analyze environmental radiation after the Fukushima Daiichi nuclear power plant accident. We evaluated the current dose rate in air at Izu-Oshima Island comparing with the data surveyed in 2005, before the Fukushima Daiichi nuclear power plant accident. As measurement items, dose rate in air (nGy/h) and radionuclide concentration in the soil (Bq/kg) were adopted. Dose rate in air was measured by fixed-point survey with pocket survey meter and car-borne survey with NaI(Tl) scintillation spectrometer. As the measurement target of radionuclide concentration, fission products Cs-134 and Cs-137 were adopted. The radionuclide concentration in the soil was measured with high-purity germanum semiconductor detector GMX10P. Mean dose rates in air of Izu-Oshima Island were 24.30 nGy/h in 2005, 36.70 nGy/h in 2011, 26.28 nGy/h in 2012 and 31.99 nGy/h in 2013, respectively. Mean radionuclide concentrations of Izu-Oshima entire area were 102.68 Bq/kg as Cs-134, 134.04 Bq/kg as Cs-137 in 2011, 52.76 Bq/kg as Cs-134, 86.78 Bq/kg as Cs-137 in 2012, 39.09 Bq/kg as Cs-134 and 72.90 Bq/kg as Cs-137 in 2013, respectively. Compared to the year 2005 before the accident, dose rate in air of Izu-Oshima Island had risen to approximately two to three times the value in 2011 after the accident, although it does not affect the island residents' health. Thereafter, dose rates in air in 2012 and 2013 were decreased more rapidly than physical half-life of the nuclides.

VARIATION OF CESIUM CONCENTRATIONS IN CEDAR POLLEN AT OKUTAMA AREA AFTER THE FUKUSHIMA DAIICHI NUCLEAR POWER PLANT ACCIDENT

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Due to radioactive contamination caused by the Fukushima Daiichi Nuclear Power Plant Accident, radioactive cesium has been incorporated into large variety of plants and soils. Cesium and potassium belong in a same group, known as alkali metals. Therefore, cesium has similar properties of potassium which is an essential element for plants to grow. There is a possibility that cesium in plants being diffused by pollen. Cedar pollen, particularly lightweight (approximately 12 ng) is known in which cesium contained. Occasionally, it flies beyond 300 km airborne. We have surveyed cesium concentrations in cedar pollen at Ome city in Okutama area, where an extensive plantation of cedar exists and counted high radiation dose from airborne measurements by the Ministry of Education, Culture, Sports, Science and Technology – Japan, for past 3 years. In this research, we analyzed variation of cesium concentrations, comparing data from 2011 to 2013. As the measurement target of cesium concentration, exclusively male flowers of cedars were adopted. To maintain sample weight certain, male flowers were sufficiently dried and ground. Powdered male flower sealed in a U-8 container was weighed and measured radioactivity concentration for 30,000 seconds making use of a germanium detector ORTEC GMX10P. Air dose in rate at 1 m above the ground surface in Ome city between the year 2011 and 2012 showed no significant difference. Concentration of Cesium-137 contained in the cedar pollen through the year of 2012 had decreased by approximately half over the previous year, which is similar result of press release distributed by Ministry of Agriculture, Forestry and Fisheries - Japan.

TERRESTRIAL GAMMA RADIATION DOSE RATE IN RYUKYU ISLANDS, SUBTROPICAL REGION OF JAPAN

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In order to explain the detailed distribution of natural radiation revel in Japan, the dose rates in air due to terrestrial gamma radiation have been measured at about a total of 8,000 points in the Ryukyu Islands, subtropical region of Japan that stretches over Kagoshima and Okinawa prefectures. The in situ measurements were carried out with NaI(Tl) scintillation survey meters at 1m in height from the soil ground on 23 islands. Also the car-borne survey has been conducted in Okinawa-jima, the biggest island of Okinawa prefecture, then the in-car data were converted into the outdoor values on the soil ground. In addition, analyses for the natural radionuclide have been performed on the representative soils and rocks collected from the islands. From the results for the measurements, arithmetic mean, the maximum and minimum of the dose rates on the soil ground were estimated to be 41 nGy h^{-1}, 165 nGy h^{-1} and 8 nGy h^{-1}, respectively. This arithmetic mean for the islands is lower than that of the whole Japan, about 50 nGy h^{-1}. The maximum and minimum of the arithmetic mean by island were also estimated to be 79 nGy h^{-1} of Miyako-jima and 28 nGy h^{-1} of Kohama-jima, respectively. Relatively high dose rates (>100 nGy h^{-1}) were particularly found in Miyako-jima, Irabu-jima, Kitadaito-jima and Minamidaito-jima which are mainly composed of the uplifted coral reef, the Quaternary Ryukyu limestone. In these islands, almost of the limestone is covered with peculiar red soils. Based on the content of natural radionuclide and the reported oxygen isotope ratio, the main material of the red soil is considered to be the East Asian eolian dust mainly transported from the high background radiation area in the southeastern part of China before the last glacial age at least. On the other hand, the dose rates on the outcrops of the limestone are evidently lower than those in the other areas. This situation is in good agreement with that the limestone is very low content in natural radionuclides. Then the results strongly suggest that the red soil is an effective enhancer for the terrestrial gamma radiation dose rate in the islands. From the result for a comparative study of car-borne data obtained prior to and subsequent to the 2011 Fukushima nuclear accident, as for Okinawa-jima, it was considered that the accident has no impact on the radiation level at the present time.

ASSESSMENT OF NATURAL RADIOACTIVITY (^{226}RA, ^{232}TH AND ^{40}K) AND RADIATION DOSE IN UTTARAKHAND HIMALAYA, INDIA.

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The exposure of human beings to ionizing radiation from natural sources is a continuing and inescapable feature of life on earth. External exposures in outdoors arise mainly from terrestrial radionuclides present at trace levels in all soils. Irradiation of the human body from external sources is mainly by gamma radiation from radionuclides in the ^{238}U and ^{232}Th series and ^{40}K, and irradiates the various organs with alpha and beta particles, as well as gamma rays. Natural radiation is the largest contributor to the collective dose to the world population. The natural radioactivity of soil samples is usually determined from the ^{226}Ra, ^{232}Th and ^{40}K contents. Due to the variation of external gamma dose rate, it is essential to measure the radionuclides content in surrounding soils samples. These doses vary depending upon the concentrations of the natural radionuclides, viz. ^{238}U, ^{232}Th, their daughter products and ^{40}K, present in the soils and rocks, which in turn depend upon the local geology of each region in the world. In present study the assessment of natural radioactivity has been carried out in different region of Uttarakhand Himalaya using gamma ray spectrometer with NaI(Tl) scintillation detector. The detail significance of this paper is also discuss from radiation protection point of view

Key Word: Effective dose, Radium equivalent activity, Terrestrial radionuclides.

GEOCHRONOLOGY OF THE IACOB LAKE (DANUBE DELTA) BY THE PB-210 AND CS-137 DATING METHODS

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The Danube Delta is the second largest delta in Europe, having a surface of approximately 4152 km^2. Analysing its sedimentation procesess is important because of the continuous changes in different time-scales caused by natural factors (sea level rise, storms, floods, droughts etc.) and anthropogenic interventions (dams, river regulations, hydro energetic power plants, meanders cut offs, artificial channels cuttings, protection walls etc.), but most importantly the construction of the Iron Gate hydroelectric power plant (1972).

Three sediment cores were analyzed from the Iacob Lake (central part of the Danube Delta) in order to apply the ^{210}Pb and ^{137}Cs radiometric dating methods on the sediment cores using alpha and, respectively, gamma-spectrometry in the determination of radionuclides of interest (^{210}Pb/ ^{210}Po and, respectivly ^{226}Ra and ^{137}Cs) to assess the sedimentation rates and the dynamics of the sedimentation processes in the Iacob lake after identifying the anthropogenic influences of the Iron Gate.

The alpha samples were made by acid digestion and then deposited on high nickel content stainless steel discs, while the gamma measurements were carried out on dried and homogenized sediments, put into aluminum boxes. The ages of each sediment core were found to be approximately identical, ranging from 2010 ± 0.2 to 1860 ± 40 years in concordance with the depth; also mass and linear sedimentation in the Iaboc Lake show a good similarity with the suspended sediment measured behind the Iron Gate.

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ORAL PRESENTATIONS

RADON MAPPING STRATEGIES IN AUSTRIA

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According to current legislation and recommendations (IAEA; WHO, EU) countries shall identify areas where the radon concentration in a significant number of buildings is expected to exceed the relevant national reference level. Identifying and defining areas with expected higher radon concentrations in buildings is fundamental for establishing legislation and future strategies.

In Austria this activity was started in the early 1990s with the Austrian National Radon Project (ÖNRAP) which yielded the Austrian Radon Potential Map, based on over 20,000 measurements, calculated for a standardized situation. In the present map the mean radon potential per municipality is displayed, classified in three classes. As there are more than 2,300 municipalities in Austria, the radon potential by municipality is often based on only a few dwellings. To use the radon potential map as a reliable basis for decisions e.g. in construction permit processes, preventive measures or prioritizing surveys, there is a need to improve the map by reducing the uncertainty of the radon potential assigned to a municipality.

Currently strategies how to improve the radon map are evaluated – such as including existing data from non-dwellings (e.g. schools) in the data pool used for the radon map and using additional data like dose rate, geology and soil permeability.

In addition, an extensive program for radon measurements in 35,000 dwellings in Austria was designed and started. The selection of dwellings is based on three criteria - a minimum number of measurements in a regular grid (2 x 2 km), geological units and municipalities, respectively. As a first step long-term radon measurements are carried out in 6,500 dwellings of members of the voluntary fire brigades in one of the federal states with highest radon potential (Upper Austria) in 2014.

In the presentation the current Austrian Radon Potential Map and the new strategies and programs are presented.

GEOGENIC RADON POTENTIAL MAPPING IN FRANCE AND FRENCH OVERSEAS TERRITORIES

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Radon-222 is a radioactive natural gas known to be the main contributor to natural background radiation exposure. Effective risk management needs to determine high radon-prone areas. The mapping of indoor radon concentrations is a method commonly used to identify the areas the most «at risk». However, radon mapping based solely on indoor measurements requires a large number of data. Therefore, an alternative and indirect method, geologically based, is sometimes used for radon mapping. In order to improve regulatory tools for radon risk management in metropolitan France and French Overseas Territories, a methodology has been developed by the IRSN (Institute for Radioprotection and Nuclear Safety) to map the geogenic radon potential (GRP) from geological criteria.

The purpose of this map is to target areas which are the most probable to produce high radon concentrations in soil-air. Thus, it brings information about the main radon source in buildings. The parameters used are not exhaustive, but allowed a harmonized method for all French territories, using existing data. This approach consists in compiling and analyzing available geological data from maps, databases, results of research, studies etc. The map is based on a qualitative classification scheme and geological boundaries. The methodology can be divided in 3 stages: (1) evaluating and mapping the radon source potential of the geological units from their uranium content (measured or extrapolated), (2) optimizing the first map by taking into account additional parameters, such as fault lines, mining galleries and shafts, thermo-mineral sites, which may facilitate the radon migration in the ground, and (3) synthetizing in a final categorization to obtain a map of the GRP.

This methodology has been applied to France (2008-2010) and more recently to all French Overseas Territories (2012-2013). We present here the results obtained which display significant variations of the GRP. The map obtained for metropolitan France has also been compared to results of indoor radon measurements. This statistical study demonstrates the major influence of the GRP on the variability of the indoor radon concentrations at a regional or national scale. The results show that there is close agreement between GRP and average indoor radon concentration. The geometric mean of indoor radon concentrations and the percentage of indoor radon concentrations above 100 Bq/m^3 or above 400 Bq/m^3, increase with GRP classes.

The maps will be of assistance to programs designed to reduce or prevent high exposures to radon and will enable definition of the radon-prone areas in France. The results also provide useful exposure data for epidemiological investigations on the health risk related to natural radioactivity exposure.

INVERSE ESTIMATION OF RADON FLUX DISTRIBUTION FOR EAST ASIA USING MEASURED ATMOSPHERIC RADON CONCENTRATION

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Our understanding of long-range atmospheric transport of trace gases and particles is still limited. We have used radon-222 as a tracer of long-range atmospheric transport. We measured radon concentration in air at Hateruma Island, which is the southern-most inhabited island of Japan at 24.04°N, 123.79°E and estimated the radon flux distribution for East Asia by using the measured radon concentrations.

An electrostatic radon monitor (ERM) has been used for the measurement of hourly atmospheric concentrations. The measurement was carried out from May 2002 to December 2013. High sensitive ERM (HSERM) has been installed from October 2011 in addition to the originally used ERM. The lower limits of detection for ERM and HSERM are about 0.5 Bq m^{-3} and 0.1 Bq m^{-3} for the hourly concentration.

The radon fluxes for East Asia were estimated with a Bayesian inverse method by using the atmospheric radon concentrations, the measured value at Hateruma Island and the calculated value with a 3-D atmospheric radon transport model MM5/HIRAT. The calculation domain was set to be 9792 km (W-E) x 7776 km (S-N) x 10 km high covering East Asian region. The region was subdivided into 16 segments. The a prior radon flux distribution was used from Schery and Wasiolek (1998).

The mean radon concentration for the entire period was 1.4 Bq m^{-3}. The measured concentrations showed a seasonal variation with maxima of 2.2 Bq m^{-3} on January and minima of 0.46 Bq m^{-3} on July. The periodic high concentrations were measured when the air mass from Asian continent arrived at Hateruma Island.

The model calculation performed for the year of 2008 in winter indicated that the radon from the region between 40°N and 50°N arrived at Hateruma Island, as well as that from the coastal regions of China did.

The mean radon flux for East Asia in January 2008 was estimated to be 34.3 mBq m^{-2} s^{-1} which was higher than the a prior value of 25.3 mBq m^{-2} s^{-1}. The radon fluxes under 50°N were estimated to be in the range from 29.2 to 65.3 mBq m^{-2} s^{-1}, which was 1.2-2.0 times higher than the a prior values. In contrast, the radon fluxes over 50°N were estimated to be 4.0-20.0 mBq m^{-2} s^{-1}, which was lower than the a prior values. It implies that the radon exhalation from a frozen soil surface is substantially suppressed that does not take into account in the Schery's fluxes.

A NEW METHOD FOR MEASURING RADON EXHALATION RATE FROM SOIL SAMPLE IN THE LABORATORY

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Radon exhalation rate from soil is an important indicator of evaluation of radon potential, but it is greatly influenced by meteorological factors. In order to accurately measure the radon exhalation rate, we established a new method to measure radon exhalation rate from soil samples in the laboratory. The test sample is placed in a sealed glass container to accumulate radon, after transferring the gas in another container, finally the radon concentration in the new container is measured by ALHPAGUARD PQ2000 after 5 hours. The radon exhalation rate is calculated by fitting radon concentration measured with different accumulating time. Ten samples have been measured for 23 times measurements. The repeated measurement results show that relative deviations for the same sample are under 2% when samples are dry; the soil radon exhalation rate of the sample and its radium content shows a good positive correlation, and the correlation coefficient greater than 0.7. Using this method can reduce the influence of meteorological factors on soil radon exhalation rate measurements in the field and improve the accuracy of measurement results.

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BI-214/PB-214 ACTIVITY RATIO IN RAINWATER FOR RESIDENCE TIME ESTIMATION OF CLOUD DROPLETS AND RAINDROPS

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Radioactivity concentrations of two short-lived radon (Rn-222) decay product nuclides Pb-214 and Bi-214 in rainwater were observed at Nagoya University, Nagoya, Japan (35° 9' 8"N, 136° 58' 25"E) for 46 rain events from Dec. 2010 to Jul 2012. Gamma emissions from the rainwater samples with a volume of 15 mL collected for every 15 min were automatically counted by an well-type NaI(Tl) scintillation detector and two single channel PHAs. The concentrations averaged for a rain event ranged 0.01-0.49 Bq/mL for Pb-214 and 0.02-0.49 Bq/mL for Bi-214, and activity ratios Bi-214/Pb-214 from 0.26 to 4.27. When Rn-222 concentration in cloud air is higher, these activity concentrations are naturally higher. On the other hand, the activity ratio Bi-214/Pb-214 in rainwater would be mainly controlled by time evolution of numbers of these nuclides, regardless of Rn-222 concentration in cloud air. A simple time evolution model were applied to 2-h averaged Bi-214/Pb-214 observations to estimate residence times of cloud droplets and raindrops with assumptions of (1) constant Rn-222 concentration in cloud, (2) immediate capture of Po-218 generated from Rn-222 in cloud into cloud droplets, (3) negligible capture of Po-218 by raindrops which are grown by incorporation of cloud droplets, (4) no contribution of wash-out (under cloud scavenging) process of Rn-222 decay products to incorporation of Pb-214 and Bi-214 into raindrops. The estimated total residence time of cloud droplets and raindrops were more than 100 min for weak rain intensities less than 5 mm/h, tens min to several hundred min for rains of 5-10 mm/h, and less than tens min for heavier rains. These estimations are consistent with times that raindrops need to reach the ground from cloud bottom with their terminal velocities calculated theoretically based on the relationship of rain intensity and representative size of raindrops.

PRELIMINARY INVESTIGATION OF RADON CONCENTRATION IN WATER IN SHENZHEN CITY (CHINA)

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The various concentrations of dissolved radon (^{222}Rn) levels in water sources are still of interested topics. It is because that the radiation will induce the public health hazards. In order to understand the levels of radon concentration in different kinds of water in Shenzhen City (SZ), Guangdong Province of China, in 2013 during the radon mapping in SZ, radon concentrations in various types of water were measured. ^{222}Rn measurements in surface and underground water sources were conducted using a portable degassing system associated with ionization chamber AlphaGUARD (PQ2000). The dissolved radon concentrations ranged from a low of 95.70±22.82 Bqm^{-3} acquired from tap water to a high of 65.16 ±7.91 kBqm^{-3} sampled from mountain areas, the arithmetic average value was 7.67±19.45 kBqm^{-3}. Of the 15 sites sampled, only two samples collected from the mountainous area had radon concentrations above 11.10 kBqm^{-3}, which is limited for radon level in drinking water by Chinese government (GB5749-2006). The radon levels of three mountainous areas were all above 1.00 kBqm^{-3}, and these values were 2.51±1.10 kBqm^{-3}, 43.92±6.32 kBqm^{-3} and 65.16±7.91 kBqm^{-3}, respectively. These high values were associated with the granite geological background where the water may run through, because U and Ra may be dissolved in water. Other 12 samples were almost shallow groundwater or surface water sources, such as ocean, lake and impoundment water. These low values ranged from 95.70±22.82 ~ 682.76±727.02 Bqm^{-3}, the arithmetic average value was 294.95±168.92 Bqm^{-3} and the geometric mean was 251.80 Bqm^{-3}. In general, as all determined radon concentrations in tap water were below the reference proposed in drinking water quality of China. It can be concluded that radon concentrations of the surface water sources in Shenzhen urban region are not high. On the other hand, at locations where water is collected directly from the mountainous area, it is advisable to avoid drinking it without any disposal measures, in order to alleviate any potential radon problem.

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Key words: Radon; Dissolved; Water; Shenzhen; AlphaGUARD

RADON MONITORING IN DRINKING WATER SOURCES LOCATED IN THE VICINITY OF KARAK THRUST, SOUTHERN KOHAT PLATEAU, PAKISTAN

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High levels of radon gas in drinking water are responsible for radiation related health hazards both through drinking and breathing. Eighty four drinking water samples from different sources including natural springs, tube wells, hand pumps and open wells in the area in close proximity to Karak Thrust in Tehsil Karak, southern Kohat plateau, Pakistan were examined with RAD7 electronic device for radon content determination. These water samples have a mean, maximum and minimum radon value of 9.4 ± 0.4, 25.1 ± 0.9, and 1.1 ± 0.2 Bq L^{-1}, respectively. Out of a total number of 84 drinking water samples analyzed 23 have radon levels greater than the EPA recommended maximum contaminant level (MCL) of 11.1 Bq L^{-1}. These include 24% from tube wells, 44% from springs, and 50% from hand pumps. Radon levels of 27% of the total samples are exceeding the EPA recommended level of 11.1 Bq L^{-1}. The mean radon concentration and mean annual effective dose due to radon in water of this study have been compared with the mean radon concentration and mean annual effective dose of earlier investigators due to radon in water from different localities of the India and Pakistan. The mean annual effective doses of all the samples are under the reference level of 0.1 mSv a^{-1} for drinking water of WHO and EU Council. It has been concluded that drinking water from all the sources within the region is usually harmless as far as radon related health hazards are concerned with exclusion of few isolated cases.

MONITORING OF ^{222}RN , ^{220}RN CONCENTRATION IN AIR AND ^{222}RN CONCENTRATION IN WATER FOR ASSESSMENT OF ANNUAL DOSE IN DOABA REGION OF PUNJAB, INDIA

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Radon and its progeny are the major sources of radiation exposure. In order to assess the radiation dose, the study of radon concentration in air and water of Doaba region of Punjab was carried out using an active electronic monitor RAD7. 12 different locations were chosen in Jalandhar and Kapurthala districts of Doaba region for continuous monitoring of radon in air and water. The concentration of indoor ^{222}Rn varies from 12.40 Bqm^{-3} to 60.7 Bqm^{-3} with an average value of 25 Bqm^{-3} which is lower than the world average recommended value. In general, indoor radon concentration are found to be well within the recommended action level of 100 – 300Bqm^{-3}.The concentration of ^{220}Rn in air varies from 17.50 Bqm^{-3} to 135 Bqm^{-3}. The concentration of radon in water varies from 1.42 Bql^{-1} to 5.24 Bql^{-1} with an average concentration of 3.16 Bql^{-1} .The mean annual estimated effective dose received by the residents of the studied area was estimated to be 0.38 mSv. The annual estimated effective dose is less than the recommended action level (3–10 mSv y^{-1}). The mean effective dose due to inhalation and ingestion of radon through water has been calculated to be 8.0 μSva^{-1} and 0.66 mSva^{-1}.

A PRIMARY THORON ACTIVITY STANDARD FOR THE CALIBRATION OF THORON MEASUREMENT INSTRUMENTS

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One of the main sources of natural radiation for humans is radon (^{222}Rn). Studies undertaken in various countries show that radon measurements may be affected by the presence of thoron (^{220}Rn). Therefore, it is necessary to estimate correctly the thoron concentration using calibrated instruments. LNHB has already produced a radon gas primary standard, using a defined solid angle alpha detection method with a solid cryogenic radon source. This method allows us to produce radon standards with a relative standard uncertainty of 0.4% across a wide range of activity. These radon standards are then used to produce a reference radon atmosphere in the BACCARA chamber at IRSN. Unfortunately, this approach is not applicable for thoron because of its short half-life (55.8 s). As a result, a new thoron reference standard has to be built to allow us to estimate precisely the thoron activity in a reference atmosphere.

The goal of this study is to design a measurement device using a silicon implanted detector (PIPS) for the measurement of thoron in air and also at low pressure. The detection efficiencies of both gas and solid decay products are estimated by the Monte Carlo method. These simulations are validated using a radon primary standard. The first simulations and measurements using various volumes have shown the limits of such a system due to the short range of alpha particles in air. These first simulations showed the influence of the measurement volume, pressure, temperature and humidity on the detection efficiency. This is the reason why each of these factors has to be monitored in our measurement system. The remaining factor is the flow-rate in the detector, to assure a homogeneous gas distribution.

To improve our system and especially the spectrum quality, we have decided to use the electrical properties of the radon and thoron decay products. These decay products are solid isotopes of polonium, bismuth and lead, produced by alpha and beta decays. As a result of charge rearrangements following the alpha and beta decays in the radon decay-chain, the decay products have a positive charge distribution with only a small proportion of neutral species. This property gives the possibility to trap most of the thoron progenies on a surface of our choice, i.e. on the detector itself or on the surfaces of the measurement volume. First experimental results show that using an electric field to trap the progenies on the silicon detector allows the acquisition of a well-resolved alpha spectrum, allowing the determination of the activity of thoron and some of its progenies.

FACTORS OF INFLUENCE IN THE MEASUREMENT OF RADON ACTIVITY STANDARDS USING AN IONIZATION CHAMBER AND A GAMMA RAY SPECTROMETER

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The primary activity measurement system of ^{222}Rn, based on the defined solid angle alpha counting (ASD) of a cryogenic solid source, developed in our laboratory [1] has recently been improved. This system allows the production of a radon standard in precisely manufactured metal containers or in flame-sealed glass ampoules. The metal containers are generally preferred as they are easy to handle and allow a non-destructive control of the activity of the source. This can be done by cryogenic gas transfer and ASD measurement, but also by gamma-ray spectrometry using a calibrated spectrometer. Nevertheless, preparation of radon standards in flame-sealed ampoules is sometimes necessary, especially for international comparisons within the Système International de Référence (SIR) of the Bureau International des Poids et Mesures (BIPM). In this system, which is the cornerstone of the international traceability of radon standards, the ampoule is placed inside a well-type re-entrant ionization chamber, and the equivalent activity is measured against very stable radium sources. The fabrication of these glass ampoules raises two important questions: i) “What is the influence of the position of the sealing point on the response of the ionization chamber?”, since it is known to be very sensitive to the geometry of the source and ii) “What is the influence of the variation in the thickness of the glass ampoule?”. To address the first point, radon standards in glass ampoules were prepared by voluntarily changing the position of the sealing point and measuring in two well-calibrated ionization chambers with different wall materials and thicknesses in order to derive the possible variation of the ionization chamber response. The second point was studied by using glass ampoules with various glass thicknesses. These ampoules were selected from a batch, by measuring the thickness of the wall using a radiation absorption method developed in our laboratory and the response of the ionization chambers were correlated with the thickness of the ampoule. This whole study allowed an uncertainty factor to be determined due to the ampoule in the SIR measurement and more generally in any measurement method based on the detection of the gamma emission of radon and progeny.

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DEVELOPMENT OF RADON AND ITS PROGENY CALIBRATION FACILITY AT NIM (CHINA)

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Accurate measurement of radon and radon progeny is the basis to control the radon dose and reduce the risk of lung cancer caused. The precise calibration of measuring instrument is an important part of the quality control of measurements of radon and radon progeny concentration. To establish Chinese national standards and realize reliable calibrations of radon and radon progeny measuring instrument, a radon chamber with regulation capability of environmental parameters, aerosol and radon concentrations was designed and constructed at NIM. The chamber has a total volume of 20 m^3 including an exposure volume of 12.44 m^3. The radon concentration can be controlled from dozens $Bq \cdot m^{-3}$ to the maximum of $232kBq \cdot m^{-3}$. The variation range of temperature, relative humidity and aerosol are from (0.66~44.39) ^oC, (16.4~95) %RH and (102~106)cm^{-3}, respectively. The main advantages of the NIM radon chamber respect to maintaining a stable radon progeny concentration and equilibrium factor in a wide range through automatically control of radon and aerosol are described.

Keywords: radon, radon daughters, metrology, calibration facility

ABSOLUTE MEASUREMENT OF THE ACTIVITY OF RADON-222 ABSORBED IN THIN POLYCARBONATE FOILS

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A new type of passive radon monitor, referred to as a "radon film badge" has recently been proposed by Tommasino and Tokonami. These monitors consist of a solid state nuclear track detector packed between thin plastic films (radon radiators). The use of plastic films to concentrate radon from the environment leads to increased sensitivity, wide linearity of response and a very compact radon monitor. The performance of the monitors is largely determined by the radon absorption properties of the film, Makrofol N thin polycarbonate film being identified as particularly suitable. The objective of this work is to show that the activity of ^{222}Rn absorbed in thin polymer foils can be precisely measured using the Triple-to-Double Coincidence Ratio (TDCR) method in Liquid Scintillation (LS) counting. In our experiments 40 μm thick Makrofol N foils have been exposed to a radon atmosphere allowing the determination of the diffusion length and the solubility of ^{222}Rn. This information was then used to determine the time needed to reach a stationary state for the radon diffusion process inside the foil. A new set of foils was then exposed to a primary calibrated radon standard atmosphere, until this stationary state was reached. Immediately following this exposure, the polycarbonate foils were placed into LS glass vials, filled with Ultima Gold F LS cocktail. These LS sources are kept for 4 hours, in order for secular equilibrium between radon and its short-lived progenies to be reached, and then counted in a TDCR LS counter. The TDCR method allows the direct determination of the activity of radon inside the source with a relative standard uncertainty lower than 1 %. The calculation of the detection efficiency is made considering the emission spectra of the ^{222}Rn decay chain, with corrections taking into account the relative activity ratios of ^{222}Rn and its solid daughters and the influence of the dead-time of the counter on the detection efficiency of the 162 μs half-life 214Po. The typical overall detection efficiency obtained is greater than 4.9. The linearity of the response, with respect to the mass of Makrofol N in the vials, was checked by comparing the activity measurements of different amounts of foil exposed to the same radon atmosphere. The absolute determination of the activity of the radon absorbed in the polycarbonate foils provides an opportunity to determine the absorption properties of this material (solubility and diffusion length) with very high accuracy. No efficiency calibration is needed and the measurement is relatively fast and does not suffer from adverse effects like desorption of radon during measurement. This method can also be applied to study the radioactive noble gas absorption properties of other plastic films. This study is the first step towards the development of a traceability chain for radon film badges to radon standards.

ESTIMATION OF EQUILIBRIUM EQUIVALENT CONCENTRATION (EEC) OF 222RN AND 220RN IN MALWA REGION OF PUNJAB

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^{222}Rn, ^{220}Rn and their attached / unattached nanosized decay products in 20 locations of Mansa, Bathinda, Muktsar and Faridkot districts of Punjab has been measured using new techniques viz., Single entry pin hole cup dosimeters and deposition based progeny sensors (DRPS/DTPS), independent of air turbulence. ^{222}Rn, ^{220}Rn and their progeny are present in the indoor atmosphere as attached and unattached fractions. The size and concentration of attached and unattached fraction of ^{222}Rn and ^{220}Rn plays a vital role in the radiation dosimetry and health risk assessment. The ^{222}Rn and ^{220}Rn concentration in study area was found to vary from 14.91 Bqm^{-3} to 194.6 Bqm^{-3} and 6.42 Bqm^{-3} to 166.8 Bqm^{-3}. The EEC (attached + unattached) of ^{222}Rn and ^{222}Rn progeny was found to vary from 3.64 Bqm^{-3} to 73.28 Bqm^{-3} and 1.08 to 57.7 Bqm^{-3}. The attached and unattached fraction has been calculated separately and discussed in detail. The equilibrium factor of ^{222}Rn in the study area was found to vary from 0.11 to 0.79.

ATMOSPHERIC ELECTRICAL CONDUCTIVITY RELATED TO RADON CONCENTRATION AT MYSORE, INDIA

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The electrical conductivity of the atmospheric is due to the presence of ions in the atmosphere and depends on the meteorological parameters. The variation of electrical conductivity near the earth's surface is mainly due to the variations of ^{222}Rn and its short-lived daughter nuclei (^{218}Po, ^{214}Pb, ^{214}Bi and ^{214}Po). Both positive and negative atmospheric conductivity, ion pair production rate due to radon and its daughters products were simultaneously studied at few locations in Mysore city (12^{o}N, 76^{o}E), India. The atmospheric electrical conductivity was measured using a Gerdien Condenser. ^{222}Rn and individual radon progeny concentrations (^{218}Po, ^{214}Pb and ^{214}Po) were measured using Low Level Radon Detection System and Air Flow Meter respectively. The electrical conductivity shows a good correlation with ion production rate with a correlation coefficient of 0.85. The diurnal variation of radon concentration and atmospheric electrical conductivity 1 m above the ground surface showed a variation from 8.8 to 20.6 Bq m^{-3} and 1.2×10^{-14} to 5.4×10^{-14} S m^{-1} respectively. The atmospheric electrical conductivities are studied at different heights up to 200 m from the ground surface using balloon borne measurements. The results show that as height increases the conductivity decreases. Maximum values were observed at a height of 0.25m and lower values were observed above 4m from the ground surface. As height increases radon concentration gradually decreases resulting in decrease of ion–pair production rate and atmospheric electrical conductivity.

A NEW TYPE OF ELECTROSTATIC INTEGRATING RADON MONITOR WITH THE CR-39 AS ALPHA-PARTICLE DETECTOR

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In this study, based on the electrostatic integrating radon monitor (EIRM) developed by T Iida, et al, a new type of EIRM with the CR-39 as alpha-particle detector was developed for airborne radon measurements. In order to improve the detection efficiency, the dially glycol carbonate (CR-39) was used to instead of the cellulose nitrate film (CN) as alpha-particle detector, and the electrode was optimally designed based on the electric field distribution calculated with the software of CST®. To minimize the humidity effect on the electrostatic collection of alpha particle, the polytetrafluoroethene film was used instead of the membrane filter. For protection of the environment, the DRIERITE® desiccants were used to replace the P_2O_5 as the dry agent. The calibration factor of the new EIRM was calculated to be 0.124±0.007 tracks•cm^{-2}•$(Bq•m^{-3}•h)^{-1}$, and the lower detection limit was estimated to be 0.3 Bq•m^{-3} for a 2-month exposure. Field experiments showed that the results of averaged outdoor radon concentrations monitored with the new EIRM and the AlphaGUARD® agreed with each other very well, and the relative humidity inside the new EIRM was observed to be almost consistent at 15% during the field measurements. The results show that the performances of the new EIRM are better than the old one, and it is suitable to be used for environmental radon surveys.

INTERCOMPARISON OF CALIBRATED CR-39 TRACK THORON PROGENY DETECTORS BY ACTIVE THORON DEVICES UNDER ON-SITE CIRCUMSTANCES

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Nowadays, besides radon and thoron more and more attention is given to identifying their progenies. This is due to the fact that radiation exposure is not primarily caused by radon isotopes but by their progenies as they stick to solid particles contained in the air and depending on their size they may deposit in different parts of the lungs. Therefore, in opposition with radon and thoron only a small part of which decompose in the lungs and most of them are exhaled the progenies are kept in the organism for a longer period.

Integral detectors based on track detectors CR-39 are the most wide-spread detectors in different surveys. However, only a relatively small number of detectors functioning by this principle have been traded; this has mainly been inhibited by difficult calibration and measurement validation. At Institute of Radioecology and Radiochemistry (University of Pannonia) the calibration of a Japanese developed thoron progeny measuring track detector has been implemented. During the calibration the value of the calibration factor was identified for three different exposition periods.

Following the calibration its successfulness also had to be ascertained. It was verified in a room previously used as a carpenter's shop in the manganese mine in Úrkút. During the measurements the parameters in the room (temperature, atmospheric pressure and humidity) have been almost constant with slight differences of 1-2 %.

During the measurement Pylon WLx monitor was used and the measurement results of this instrument were compared with the results provided by the track detectors previously calibrated. During the comparison it was found that the measurement results gained by the two instruments showed great correspondence: the difference between the concentration values measured by the two monitors was 10 %.

DEVELOPMENT OF ^{222}RN/^{220}RN CONTINUOUS MONITOR BASED ON ELECTROSTATIC COLLECTION METHOD

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The ^{222}Rn/^{220}Rn continuous monitor based on electrostatic collection method was developed in order to measure ^{222}Rn/^{220}Rn rapidly and reliably. The releasedα-particles energy from ^{218}Po, ^{216}Po and ^{212}Po was discriminated by PIPS detector and three single channels. Temperature's effect on the photo-peak efficiency of semiconductor detector was eliminated by using the threshold automatic adjustment method, and humidity's effect on the detection efficiency was eliminated by the temperature/humidity self-compensation method. Meanwhile, the rapid and reliable measurement was achieved by using large flow capacity and iterative correction method. Compared with the reference measurement of Radon Laboratory in the University of South China in two cases, i.e., ^{222}Rn concentration is 2000Bq/m^3 and ^{220}Rn 1300Bq/m^3, it was shown that the relative deviation of ^{222}Rn and ^{220}Rn was within 5% and 9% respectively using the ^{222}Rn/^{220}Rn continuous monitor based on electrostatic collection method at the temperature from 0^{o}C to 40 ^{o}C and in the relative humidity from 0% to 90%.

STUDY ON THE CONTINUOUS MEASUREMENT METHOD OF RADON AND THORON PROGENY CONCENTRATION BASED ON ALPHA SPECTROSCOPY

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In order to simultaneous and continuous measurement the concentration of ^{222}Rn and ^{220}Rn progeny in special places, a new method based on the α spectroscopy without replacing membrane frequently is established by introducing the cumulative activity function. A comparative study was carried out between the new method and the traditional standard method in measuring the concentration of ^{222}Rn and ^{220}Rn progeny progeny in the radon laboratory of university of south china.The experimental results show that the continuous measurement method has a better ability to identify ^{222}Rn and ^{220}Rn progeny, and the results obtained from the continuous method and the reference method are highly consistent, an the new method works five measurement cycles without changing the membrane. In the process of sampling, the impact on membrane self-absorption from aerosols being deposited on the membrane surface could be ignored.

STUDY ON PEAK SHAPE FITTING METHOD IN RADON PROGENY MEASUREMENT

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Alpha spectrum measurement is one of the most important methods to measure radon progeny concentration in environment. However, the accuracy of this method is affected by the peak tailing due to the energy losses of alpha particles. Traditional peak tailing correction method is used to solve this problem, but the correction factors of this method vary with the setting of alpha energy window and the proportion of $^{222}Rn/^{220}Rn$, and its applications are limited.

This paper presents a peak shape fitting method, which can overcome the peak tailing problem in most situations. On typical measured alpha spectrum curve, consecutive peaks overlap even their energies are not close to each other and it's difficult to calculate the exact count of each peak. The peak shape fitting method uses combination of Gaussian and exponential functions, which can depict features of those peaks, to fit the measured curve. It can provide net counts of each peak explicitly, which was used in Kerr method calculation procedure for radon progeny concentration measurement.

The results show that the fitting curve fits well with the measured curve and the influence of the peak tailing is reduced. The method was further validated by the agreement between radon EEC concentration based on this method and the measured values of some commercial radon monitors, such as EQF3220 and WLx. In addition, this method improves the accuracy of individual radon progeny concentration measurement. Especially for the ^{218}Po peak, after eliminating the peak tailing influence, the calculated result of ^{218}Po concentration has been reduced by 21%.

ESTIMATION OF THE FRONT-TO-TOTAL ACTIVITY RATIO FOR WIRE SCREENS USING CFD SIMULATION

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The wire screens are widely used for sampling radioactive aerosols. By detecting the alpha particles emitted from the radon progenies attached on aerosol particles, the graded screen array (GSA) is an effective method to monitoring the particles size distribution of the aerosols. Due to the shielding effect of the wire screens for alpha particles, the front-to-total activity ratio is a critical factor for measuring the activity of the deposited aerosols accurately. However, in most studies on aerosols collection using screens, the front-to-total activity ratios of the different screens had not been fully discussed.

In this study, the computational fluid dynamic (CFD) method was applied to simulating the deposition of aerosols onto the surface of the wire. 4 different types of screens were investigated when the particles size varied from 1nm to 10μm. By analyzing the angle distribution of deposited aerosols, the front-to-total activity ratio was estimated. Some verification experiments were carried out in the radon chamber under different size distribution of the aerosols. Using the imaging plates as the detector, the front-to-total activity ratio of 30-mesh, 60-mesh, 200-mesh and 400-mesh wire screen were measured respectively.

The results showed that the experimental data well coordinated with the simulation. It indicated that there were significant differences on the front-to-total activity ratio for the different types of screens. Due to the Brownian diffusion, the smaller aerosol particle deposited on the surface of the wire cylinder more uniformly, which lead to relatively lower front-to-total activity ratio. For the aerosol particles larger than 1μm, the front-to-total activity ratio of screens increased rapidly with the growth of the particle size.

VARIATION IN 222RN EXHALATION RATE FROM SOIL SAMPLES OF TEHRI GARHWAL, INDIA

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Radon is released from the grains of soil and rocks to the environment and governed by its emanation and exhalation from the soil. The most important factor, controlling exhalation of radon from soil is geological structure of the top layer of the ground. In this paper, the values of radium activity and radon mass exhalation from soil samples of Tehri region, Uttarakhand are presented. The measured values of ^{226}Ra activity and ^{222}Rn exhalation rate were found to vary from 31±6 Bq/kg to 67±8 Bq/kg and 9.93×10-7 Bq.Kg^{-1}h^{-1} to 1.04×10^{-5} Bq.Kg^{-1}h^{-1}, respectively. A strong positive correlation was observed between radium activity and radon exhalation rate from the soil. The variation in radon mass exhalation rate in relation to geological structure of the study area is discussed in this paper.

STUDIES ON RADIUM AND RADON CONCENTRATIONS IN DRINKING WATER SAMPLES OF CHAMARAJANAGAR DISTRICT, KARNATKA STATE, INDIA

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^{222}Rn is a colorless, odorless, radioactive noble gas, and continuously produced in soil, rocks, and water by the natural decay of ^{226}Ra. The amount of radon that emitted from the earth's surface depends mainly on the amounts of ^{238}U, ^{232}Th and ^{226}Ra and also the type of the soil and its porosity. ^{226}Ra is an alpha emitter, which contribute significant amount of dose to living beings, through ingestion of water in to the body. Greatest health risk from radium is significant exposure of mankind to its radioactive decay product radon. Long time exposure of population to higher levels of radon and its progeny leads to occurrence of lung cancer and other pathological effects. In the present study the measurements of ^{226}Rn and ^{222}Rn concentration in drinking water samples of Chamaraja Nagar district, of Karnataka state, India were made. The study area is Chamaraja Nagar district, located in the southern tip of Karnataka state, India, and lies between North latitude 11º 40' 58" and 12º 6' 32" and East longitude 76º 24' 14" and 77º 64' 55". About 100 samples (20 liters in each location) of water were collected from different locations of the study area and determination of 226Ra and 222Rn were made by the method of emanometry. The concentration of radon in water samples in the study area are varying from 1.59-252.17BqL^{-1}, with a median of 18.165BqL^{-1}. The concentration of radium in water is varying from BDL to 81.89 mBqL-1, with an average value of 26.439 mBqL^{-1} and median value being 11.7mBqL^{-1}. The Inhalation dose due to radon varies from 4.01-635.47μSv with median of 40.824μSv. The Ingestion dose due to radon varies from 0.33-52.96μSv, with a median of 3.184 μSv, and the median value of effective dose due to radon 49.59 μSv.

IMPROVEMENT IN THE ^{222}RN RESPONSE VERSUS TIME DURING SHARP CONCENTRATION CHANGES

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^{222}Rn and ^{220}Rn can be used as tracers of groundwater or submarine springs, and ^{222}Rn in water could indicate the indoor radon problem in some region. The half-life of ^{222}Rn is long enough so that its concentration could be maintained during transport over relatively long distances. ^{222}Rn and ^{220}Rn in water can be automated analyzed by a modified RAD AQUA (Durridge Inc.) system. The researchers found that it takes about 15 minutes for the radon to achieve gas equilibrium at a water flow rate of 17.5 L/min. This is equivalent to the time required for the ^{222}Rn-^{218}Po pair to approach radioactive equilibrium. In this paper, we will introduce the algorithm for quick and continuous tracing the change of radon concentration in environment, and present here results from a laboratory experiment intended to improve the ^{222}Rn response versus time during sharp concentration changes. We find that the corrected radon concentrations can response the sharp concentration changes immediately. However, the corrected radon concentration is 4485Bq/m^3 in the period from the 48th minute to the 56th minute when the radon concentration just drops down to zero. The great error of the corrected radon concentration in this period is from the large error of the ^{218}Po concentration at the end of last period.

MEASUREMENT OF RADON AND THORON PROGENY CONCENTRATIONS IN DWELLINGS OF TEHRI GARHWAL, INDIA USING LR-115 DEPOSITION BASED DTPS/DRPS TECHNIQUE

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This paper presents the values of radon and thoron progeny concentrations for different seasons in the dwellings of Tehri Garhwal, India. The measurements have been carried out using LR-115 solid state nuclear track detector based passive time integrated DTPS/DRPS technique. In summer, the radon and thoron progeny have been found to vary from 1.3 Bq/m3 to 88.2 Bq/m^3 with an average of 30.5 Bq/m^3 and 0.2 Bq/m^3 to 11.3 Bq/m^3 with an average of 3.1 Bq/m^3, respectively. In rainy season, the radon and thoron progeny have been found to vary from 1.5 Bq/m^3 to 146.5 Bq/m^3 with an average of 30.9 Bq/m^3 and 0.1 Bq/m^3 to 30 Bq/m^3 with an average of 5.1 Bq/m^3, respectively. In autumn, the radon and thoron progeny have been found to vary from 6 Bq/m^3 to 137.4 Bq/m^3 with an average of 40.9 Bq/m^3 and 0.1 Bq/m^3 to 7.5Bq/m^3 with an average of 2.1 Bq/m^3, respectively. In winter, the radon and thoron progeny have been found to vary from 0.2 Bq/m^3 to 129.8 Bq/m^3 with an average of 22.3 Bq/m^3 and 0.3 Bq/m^3 to 3.2 Bq/m^3 with an average of 1.2 Bq/m^3, respectively. It has been observed that the average value of radon progeny concentration is almost constant in summer to rainy seasons. However, it increases in autumn, followed by a decrease in winter. The average value of thoron progeny concentration has been found to higher in summer and rainy seasons and lower in rainy and winter seasons. The seasonal variations in radon and thoron progeny concentrations in different houses are discussed in details.

IS THORON A PROBLEM IN SWEDISH DWELLINGS? RESULTS OF MEASUREMENTS OF CONCENTRATIONS OF THORON AND ITS PROGENIES

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Thoron (Rn-220) levels in Swedish dwellings have barely been studied for various reasons. The few studies performed on Rn-220 in Sweden included few measurements in areas where an enhanced concentration of thorium was known to occur in the geology. The present study aims to provide more knowledge on levels of thoron and thoron progenies concentrations in Swedish dwellings and to investigate possible health implications. This study is not targeted to areas of specific geology, but instead strives to estimate mean values of concentrations of thoron and thoron progenies prevailing in Swedish houses.

For the determination of thoron concentrations, passive integrated thoron detectors were used in combination with one detector for measurement of radon only. The thoron detectors were placed at a distance of 1 cm and 5 cm from the wall. Thoron progenies were measured using the modified monitors by NIRS, in which four CR-39 chips mounted on an aluminium plate and covered by aluminium mylar films were used. Measurements were performed in 150 dwellings, out of which 120 were detached houses and 30 were apartments. In addition to thoron and thoron progenies concentrations, radon and gamma radiation were also measured for correlation analyses. Radon gas concentrations were measured in the middle of the room, using etched track detectors. The purpose was to determine the annual mean concentration of radon gas in the studied dwellings. Gamma radiation was measured using a detector based on optically stimulated luminescence (OSL) and the detector was placed together with the thoron detectors and close to the wall. All measurements were carried out during a period of three months.

Preliminary results based on 104 detached houses and 27 apartments show that the mean concentration of thoron gas in detached houses was 62 Bq/m^3 at 1 cm from the wall and 36 Bq/m^3 at 5 cm from the wall. In apartments, the corresponding values were 54 Bq/m^3 (1 cm) and 20 Bq/m^3 (5 cm). The highest concentration of thoron measured was in an apartment and the concentration exceeds 600 Bq/m^3, both at 1 cm and 5 cm from the wall. Results of thoron progeny concentrations are being evaluated and will be presented in the conference paper. Dose estimations as well as health implications will be evaluated from the measurement data obtained.

AN INVESTIGATION OF THE CAUSES FOR THE SEASONAL AND ANNUAL VARIATIONS OF INDOOR RADON CONCENTRATIONS

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Indoor radon concentrations exhibit strong variations on short and long timescales. Besides human influences, meteorological factors significantly affect the radon concentrations indoors as well as outdoors. To assess the character of the long-term variations we have conducted continuous radon measurements in several dwellings over more than 8 years. We find strong annual variations, which take a very similar course in different buildings located in largely separated regions in Switzerland. Also the seasonal variations can be very significant reaching deviations of more than 100% in some cases. These results imply that the choice of the measuring season for radon measurements lasting less than one year is very crucial. We also investigate whether seasonal correction factors can alleviate the effects of seasonal variations on the determination of an annual average of the radon concentration. The annual variations can primarily be attributed to human influences. On the other hand specific weather conditions have an impact on the behavior of residents and we provide evidence for the assumption that they significantly contribute to the general development of radon levels in different locations.

In order to further investigate the connection between indoor and outdoor radon levels and meteorological factors we have started a measuring campaign in two buildings located in two different regions in Switzerland exhibiting different climatic characteristics. At both locations we continuously monitor the radon concentrations in several rooms and outdoors with electronic instruments. In addition we have set up weather stations at both locations surveying the local weather conditions. Since both houses are uninhabited we can conduct measurements in rooms, which are completely unaffected by human activity and where the fluctuations of the radon levels can directly be attributed to the local weather. We find evidence for a relation between outdoor air density and indoor radon concentration, which we trace back to the outdoor radon level, i.e. the more radon emanates from the soil outside of the building the less radon is present in the indoor air. Consequently, seasonal changes in the outdoor radon level are reflected in seasonal changes of the radon concentration indoors. A strong relation between outdoor and indoor radon exhalation rates is further suggested by a relation between wind strength and direction and indoor radon concentration.

We present the major results of our investigations, which provide strong evidence for correlations between outdoor and indoor radon levels and weather conditions, contributing to seasonal and annual as well as short-term variations in indoor radon concentrations. These findings could lead to a better understanding of the impact of meteorological factors on radon levels and ultimately to a better assessment of their variations.

CHARACTERISTICS OF INDOOR RADON, THORON AND THEIR PROGENIES IN A JAPANESE DWELLING

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Characteristics of radon, thoron and their progenies were investigated in different air conditions by turning four types of indoor-air appliances on and off in a two-story concrete Japanese dwelling. The four appliances were: air-conditioner, air-cleaner, gas heater and cooker hood. The measurements were done by using three devices: [1] a solid state alpha detector for continuous measurement of indoor radon and thoron concentrations [2] a ZnS(Ag) scintillation counting system for equilibrium equivalent radon concentration (EERC) and [3] a technique with CR-39 detector for equilibrium equivalent thoron concentration (EETC). Throughout the entire experiment, the cooker hood was the most effective in decreasing indoor radon concentration over a long period time, while the air-conditioner did not affect the concentration of radon. However, the results measured in each air condition will differ according to the life styles and activities of the inhabitants. In this study, indoor radon, thoron and their progenies in a Japanese dwelling will be were characterized by the different air conditions.

MEASUREMENT OF INDOR RADON, THORON AND THEIR PROGENY CONCENTRATION IN RESIDENTIAL HOUSES OF SHAHJAHANPUR AND HARDOI DISREICTS OF UTTAR PRADESH

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Concentration of indoor radon, thoron and their progeny have been measured in residential houses of Shahjahanpur and Hardoi districts of Uttar Pradesh, India using solid state nuclear track detector(SSNTD). Radon is a ubiquitous naturally occurring radioactive gas present in our environment both indoor and outdoor. It emanates from rocks and soil and tends to concentrate in enclosed spaces like underground mines or homes. Soil gas infiltration is recognized as the most important source of residential radon. Other sources, including building materials and water extracted from wells, are also important in some circumstances. Radon is the major contributor to the ionizing Radiation dose received by the general population. The inhalation dose due to radon and thoron are contributed predominated by their decay products. Hence the cumulative decay product concentrations are the actual measures of exposure. In the present study the value of radon varied from 15.07 Bq/m^3- 91.91 Bq/m^3 with an average of 50.12 Bq/m^3 while thoron varied from 10.87 Bq/m^3- 31.25 Bq/m^3 with an average of 18.58 Bq/m^3. The value radon progeny varies from 8.11 Bq/m^3- 24.79 Bq/m^3 with an average of 15.31 Bq/m^3 while thoron progeny 0.13 Bq/m^3- 2.02 Bq/m^3 with an average of 1.01 Bq/m^3. The value of equilibrium factor for radon varies from 0.13- 0.76 with an average of 0.35 while for thoron varied from 0.01 – 0.12 with an average of 0.06.

INHALATION DOSE ESTIMATION DUE TO 222RN/220RN EXPOSURE USING SINGLE ENTRY PIN HOLE BASED DIFFUSION CHAMBERS

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In the present study, newly designed Single entry Pin hole based diffusion chambers; being independent of high turbulent environmental conditions as well as with same entry rate of ^{222}Rn and ^{220}Rn; have been used to estimate the annual effective dose due to ^{222}Rn and ^{220}Rn exposure received by the residents of Doaba region of Punjab. The device has been calibrated at Bhabha Atomic Research Centre, Mumbai following the standard procedures to correlate the number of tracks registered in the LR-115 detector placed in the two chambers to the ^{222}Rn and ^{220}Rn concentration in the environment. The average values of ^{222}Rn and ^{220}Rn concentration in the indoor environs are 54.12±1.82 Bqm^{-3} and 21.99± 4.13 Bqm^{-3} respectively. The values lies within the recommended level of ICRP, 2009 (200 – 300 Bqm^{-3}) .However, the average value of ^{222}Rn concentration in the indoor environ has been found to be higher than the world average value of 40 Bqm-3 (UNSCEAR, 2000). The inhalation dose due to indoor ^{222}Rn, ^{220}Rn varies from 1.33mSva^{-1} to 8.06 mSva^{-1} with an average value of 2.32 mSva^{-1}.The annual effective doses due to exposure to indoor ^{222}Rn and ^{220}Rn progeny varies from 0.48 mSva^{-1} to 4.09 mSva^{-1} with an average value of 1.13 mSva^{-1}. The values lie well within the recommended limits (ICRP, 1993).

DEPOSITION OF RADON PROGENY ONTO DIFFERENT SURFACES IN THE THERMAL GALLERY GASTEINER HEILSTOLLEN

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In the Gastein valley, radon-rich air and thermal water have been used for therapeutic purposes for various diseases, particularly for the treatment of rheumatic diseases. Radon and Radon progeny (Rnp) exposure is a combination of inhalation and deposition of Rnp on the skin of patients. Data on short-lived Rnp deposition in the Thermal gallery are almost non-existent as they are laborious to collect under the climatic conditions of high temperatures and humidity close to saturation in the spa environment. Thus, the main objective of the present study was to measure on the deposition of Radon progeny on different well defined organic and inorganic surfaces such as paper, PVC and aluminum, in order to extrapolate these results to Rnp deposition on the human skin. The activity concentrations were measured by alpha spectrometry and weighted least square fitting of the total counts in intervals of 1 min to the decay equations to calculate the concentrations of ^{218}Po, ^{214}Pb and ^{214}Bi/^{214}Po and their deposition velocities.

The results suggest that the deposition velocities onto surfaces depend on the type of material exposed to Radon and Rnp. For paper the deposition velocity varies between 1.9 and 6.9 m/h, for skin between 2.9 and 9.2 m/h. The deposition velocities onto PVC and aluminum are comparable to the skin data.

EVALUATION OF OCCUPATIONAL EXPOSURE TO RADON AND THORON ACTIVITY IN AIR AROUND A NUCLEAR RESEARCH FACILITY

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Studies of exposures to radon and thoron have shown significant increase in the risk of lung cancer in human beings and the highest exposure usually results from inhalation of radon and its progeny. In this study, RAD7® electronic radon detector was employed in the evaluation of radon and thoron levels in a nuclear research workplace under varying ventilation conditions with the objective of ascertaining the cumulative activity concentration in air emanating from building and other materials within area. The results obtained showed that the mean value recorded for radon was 53.2±12 Bq/m3and 27.3±1.2 Bq/m^3 for thoron. Radon concentration was observed to have increased after working hours when windows of offices and laboratories were closed/locked and ventilation within were lowest, while thoron level increases during working hours when offices were ventilated and air conditioners were on. Average cumulative radon and thoron values recorded at all temperatures and relative humidity is 57.4±3.4 Bq/m^3 and 10.4±2.1 Bq/m^3, respectively. The study also showed that personnel working in the sample preparation laboratory have the highest possibility of radon and thoron exposure/effects while the least exposed are those working around the administrative offices. Activity alone is not a determining factor but exposure time and ventilation conditions of these locations. Average Working Level Month (WLM) obtained for radon and thoron at the study area for highest exposures values are 0.789 and 0.587, respectively. These values are far below the EPA, NRC and USDOE values of 4 and 12WLM per year for radon and thoron, respectively.

STUDIES ON VARIATION OF RADON CONCENTRATION -INFLUENCED BY GEOLOGY, MINING ACTIVITY AND GROUND WATER IN SOME PARTS OF KARNATAKA STATE, INDIA

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Environmental pollution and management of water is a national and international priority today. Our environment is continuously irradiated by cosmic rays and naturally occurring primordial radionuclides present in the earth's crust. ^{222}Rn, a radioactive noble gas produced by decay of ^{226}Ra, is a member of the ^{238}U series. Radon and its progenies in the atmosphere are of most important contributor to human exposure from natural sources. Radon concentration measurements in water and atmosphere are necessary to understand the effect of ^{222}Rn on human health. According to USEPA and WHO studies, radon is the second leading causes of lung cancer after smoking. The high concentration of radon in ground water poses a potential health risks in two ways by inhalation and ingestion. The radon concentration in the atmosphere is mainly depends upon the geophysical and meteorological parameters. The indoor radon concentration is depends on activity of radium content present in rocks, soil, building materials and ground water supply. The entry of indoor radon is influenced by soil fractures, stoma and fissures, ventilation condition, type of building materials used for construction and permeability of the substances. In the present study, the radon concentration in indoor air atmosphere and in drinking water have been determined by collecting various drinking water samples from bore well, tank, tap and river water from different locations in parts of Karnataka state and were estimated by using Solid State Nuclear Track Detector (SSNTD) technique and Emanometry technique. The activities of primordial radionuclides were determined by HPGe detector. The study area includes Ramanagara, Tumkur, Chitradurga, Shimoga and Bellary districts and these areas are mainly attributed by Granite rocks, schist and gneiss. The Bellary district is rich iron and manganese ore reserves and is mainly attributed by schist belt and is known as Sandur schist belt. The present study highlights the variation of indoor radon concentration with water used for domestic purposes, radium content present in rocks, soil and building materials and their properties. The mining activity is also responsible for enhancing the radon concentration in atmosphere. The result shows that in granite regions and mining activity areas shows higher radon concentration compare to other location. The estimated total equivalent effective dose is slightly higher than the global average. According to US EPA and WHO report majority of the drinking water samples and their radon concentration exceeds the reference levels.

POSTER PRESENTATIONS

RADON IN SOIL GAS: DISTRIBUTIONS AND CORRELATIONS WITH THE LITHOLOGIES AND PEDOLOGIES OF RMBH - METROPOLITAN REGION OF BELO HORIZONTE - MINAS GERAIS - BRAZIL

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The radon concentration in soil gas is directly dependent on the radium concentration in the soil, as the most important factor, and also dependent on the geological features of the area, such as lithology, pedology and on the geochemical and mineralogical local conditions. The objective of this work was to investigate the distribution of radon concentration in soil gas and its relation with the pedologies and lithologies of RMBH. For this purpose, the radon concentrations in soil gases were determined by using an AlphaGUARD monitor at 150 measurement points distributed over the lithologies and pedologies of the RMBH. In soil samples of the same measurement points, the concentrations of ^{226}Ra were determined by Gamma Spectrometry (HPGe), and U and Th by Mass Spectrometry with Ion Coupled Plasma (ICP-MS). Also the permeabilities of the soil for their natural gas were determined by using the RADON-JOK permeameter. Regarding lithologies, areas where the bedrocks are predominantly schists and metagraywackes have presented the highest radon concentrations in soil gas, with arithmetic mean equal to 46.5 ± 9.9 kBq.m^{-3}. Regarding lithologies, areas of predominantly rocky basement schists and metagraywackes had the highest concentrations of radon in soil gas, with arithmetic mean equal to 46.5 ± 9.9 kBq.m^{-3}. The concentration of radon in the soil gas was confirmed as a good indicator to predict the radon geologic potential of the area, indicated by the Geological Radon Potential - GEORP and Soil Radon Index - SRI. However, the results obtained in this study indicate the need for further experiments in certain lithologies and pedologies involving larger samples.

ANNUAL DOSE FROM RADON IN SOME PLACES OF ULAANBAATAR CITY

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Today, the research of radon is one of the most important themes in nuclear physics and environmental science. Research in indoor air radon and outdoor air radon are very significant for hygiene. Outdoor air radon changes with geographical region, season, month and hours of day. And indoor air radon pertains from outdoor air radon, buildings material and ventilation.

Experimental data of determination Rn-222 by Scintillation method (SAC-4) in outdoor air, in premises of a microtron MT-22, other working rooms and dwellings (concrete, brick, wooden and Mongolian ger) are considered. With the purpose of research of radiation safety in indoor and outdoor of the microtron, we have developed a technique of determination radon and its short-lived decay product Po-218 by the scintillation counter SAC-4. Concrete, brick, wooden, mongolian ger 4 buildings radon concentration in winter (November and December) of 6 years, measurements 400 points average to cause to out average and annual dose rate from radon are measured. Radon concentration has in outdoor air (winter) 18.7 (2.3 - 38.8) Bq/m^3. Indoor air (concrete, brick, wooden, Mongolian ger) radon concentration has 26.0 (8.2 - 42.6) Bq/m^3. Received dose rate annual to human of radon 0.8 (0.33 - 1.26) mSv/year. This concentration is less than maximum effective dose (2.5mSv/year [1]) of human year.

Mongolian National Standard “Method of determination of radon concentration in air” (MNS5246:2003) is processed and certified. The work is carried out at the Nuclear Research Centre of the National University of Mongolia.

THORON-SCOUT THE FIRST DIFFUSION BASED RADON AND THORON ACTIVE MONITOR FOR LONG TERM MEASUREMENTS IN BUILDINGS

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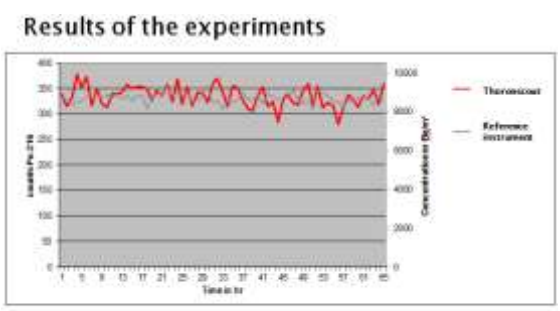
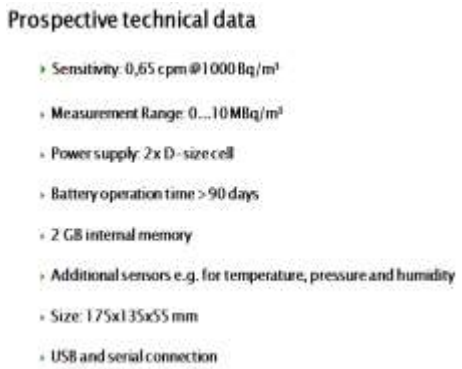
The chemical element radon has two radiologically important isotopes that occur in nature: radon-220 (known usually as Thoron) and radon-222 (simply Radon). Radon and its short-lived progeny (decay products) are continuously produced by decay of radium-226, a member of the naturally occurring uranium-238 series. Airborne concentrations of radon's short-lived progeny are of interest due to their potential for deposition in the lung, leading to subsequent irradiation of lung tissue by alpha emissions from polonium-218 and polonium-214. Thoron and its short-lived progeny are produced naturally and continuously from decay of thorium-232. In contrast with radon, substantially less Thoron reaches the breathing zone because of its short half-life (56 seconds compared with 3.8 days for radon). Because of the short half-life time it is difficult to measure Thoron, but his contribution to the dose can reach in some places high values. The first diffusion based Radon and Thoron active Monitor for long term measurements in buildings will presented. The main problem of such diffusion based device is to find a fast gas transfer membrane to allow the fast diffusion in the measuring chamber. Using the experience of the well know radon monitor RadonScout including the spectrometric electronic of the device RTM1688-2, we created with the on top light tight mounted measuring chamber covered by the fast transfer membrane the ThoronScout.





RADON STUDIES IN UKRAINE

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The first studies indoor radon levels in dwelling started in 1989. Metrology and methodological bases for indoor radon measurements were created at this step. The regularities for formation indoor radon levels were studied. As the basis for control of radon levels was selected passive track method. The quality assurance system for indoor radon measurements has been developed and implemented to practice.

Studies examined more than 30 000 dwellings now. Analysis of results found 19% cases exceeded indoor radon EEC 100 $Bq.m^{-3}$ (radon gas =250 $Bq.m^{-3}$) and 5% cases - 200 $Bq.m^{-3}$ (radon gas =500 $Bq.m^{-3}$). Areas with high levels of radon have been identified.

One of these areas (Kirovograd oblast) was selected for pilot project to reduce radon risks in 2010.

This project includes some stages: training for professionals about radon risk, measurements of radon levels in schools and kindergartens (was examined more 1000 objects), justifications for radon countermeasures and its implementation.

Authentically established that frequency distribution is lognormal. Geometric mean of indoor radon EEC was 63 $Bq.m^{-3}$, standard deviation – 82 $Bq.m^{-3}$. Indoor radon EEC ranged from 22 to 809 $Bq.m^{-3}$. Found that national regulation for this type of dwelling exceeded more 50% cases.

Currently implementing second phase of the project aimed remediation and reducing radon levels.

QUANTITATIVE EVALUATION OF INDOOR ^{218}PO BEHAIVIOR

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Inhalation of the unattached and the aerosol-attached fractions of 222Rn decay products causes internal exposure. In the indoor environment, the concentration of 222Rn decay products is determined mainly by radioactive decay, ventilation, attachment to aerosols and deposition on floors and walls. It is, therefore, necessary to quantitatively understand each process experimentally for detailed modeling of indoor behavior of the decay products. In an actual indoor situation, these processes are so complexly interdependent that quantitative evaluation of each process is difficult. The purpose of this study is to investigate the aerosol-attached and unattached 218Po behaviors by a series of experiments in a booth in which ventilation and emission of aerosols are controlled and by simulations with a numerical indoor 218Po behavior model. The effect of incense smoke on the behavior of the decay product is also investigated experimentally.

The indoor 218Po behavior model considers the production and decay of 218Po, the attachment of the unattached 218Po to aerosol particles, the deposition of attached and unattached fractions onto floors or walls and the removal by filters of instruments for 222Rn and 218Po concentrations in addition to radioactive production and decay. The attachment rate and the deposition rate of unattached 218Po were determined by statistically comparing the activity concentrations of 218Po between measurements and calculations. In the model calculations, we used measured 222Rn concentration as input data. It was also assumed in the model that the attachment rate was proportionate to the non-radioactive aerosols concentrations and the deposition rate of the aerosol-attached fraction by deposition was same as that of the non-radioactive aerosols.

A high 222Rn concentrations environment was made in the booth and concentration was measured for 222Rn, 218Po, and aerosols (0.3-0.5 μm). The model successfully reproduced the decrease of measured concentrations, and the removal rate of the unattached 218Po was estimated to be 40 h-1, and the attachment rate to be 14 h-1 at the aerosol concentration of 1.0×107 m-3. For the case with incense smoke, the model calculation showed poor agreement with the measurement. This difference is considered to have been caused by the diameter-dependent removal rate, which was not considered in the model. The low-pressure cascade impactor measurements in the incense smoke case showed substantial increases in the activity concentrations in the small diameter range less than 280 nm.

RADON POLLUTION SURVEY OF THE URANIUM WASTE DUMPS IN CHINA

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The radiation environmental quality assessment of uranium mining and metallurgy for 30 years showed that the uranium waste rock and tailings was one of the environmental radioactivity sources, the radon emanated from whose surface was the main nuclide to cause the radiation exposure of residents. In this paper, the radon exhalation rate and the radon concentration in the surrounding atmosphere of eleven waste dumps in use or retired of a uranium mine in China had been measured and compared. Also the annual effective dose caused by atmospheric radon had been estimated.

According to the annual effective dose calculation formula:

$HE = Ceq(Rn) \times Q \times N$

HE - annual effective dose, mSv/yr.

Ceq (Rn) - balance equivalent radon concentration, Bq/m^3;

Q - effective dose coefficient, 9 $nSv \bullet m^3 / (Bq \bullet h)$;

N - residence in hours, outdoor for 1760 h/yr.

The calculated value was 0.69 mSv/yr.

By situ measurement and laboratory data analysis, the following conclusions could be obtained:

(1) The eleven uranium waste rock dumps all located in remote places, which is of traffic inconvenience and few people in and out. The radon exhalation rate value from waste dumps in use was higher than the management limit prescribed by the chinese government , and the retired waste dump after the treatment was within the management limit level.

(2)The radon exhalation rate could be greatly reduced when the waste dumps were covered by soil, therefore, there is an advice that the waste dumps in use could be covered with the soil at short intervals to reduce the amount of radon exhalation, and to lower the radon harm to the staff and the surrounding people.

(3) When the waste dumps located in high and good ventilation place, the surrounding radon level was significantly lower, so the waste dump site should be chosen in the places which is high, far away from the emission sources and good in ventilation.

(4) In this survey, the average radon concentration above the eleven uranium waste dumps was 72.35 Bq/m^3, and the annual effective dose value was 0.69 mSv/yr, so the staff worked near the waste dumps should pay attention to self-protection measures.

ASSESSMENT OF INDOOR RADON CONCENTRATION IN THE VICINITY OF MANYONI URANIUM DEPOSIT IN SINGIDA, TANZANIA

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The recent development in the exploration and mining at Mkuju river uranium project, Bahi and Manyoni in Singida, Tanzania has serious radiological challenges to the society. As ^{222}Rn gas particles disintegrate they tend to build up more in homes when not well ventilated. The objective of this study was to assess indoor radon concentrations in the vicinity of the Manyoni Uranium deposit, Singida. Many people have continued to work and live above, near and around the uranium deposits, phosphate mines, coal mines without knowledge of the dangers posed to their lives. Indoor radon concentrations measurements were carried out for two months 32 houses in the vicinity of Manyoni Uranium deposit and 9 houses at Manyoni town using, a portable radon gas monitor (Alpha – GUARD)TM. Indoor Radon concentrations were found in the range of 27±3 to 518±28) Bq/m^3 with the overall mean of 166±12 Bq/m^3 which is above recommended values of 100 Bq/m^3 and 148 Bq/m^3 set by WHO and EPA, respectively. The results of overall mean indoor radon concentrations from each village were Kipondoda (169±13 Bq/m^3), Muhalala (177±16 Bq/m^3), Mwanzi, (287±13 Bq/m^3), Mitoo (325±21 Bq/m^3) and Majengo (377±23 Bq/m^3) which exceed the limit set by WHO and EPA. The value of 325±21 Bq/m^3 and 377±23 Bq/m^3 from Mitoo and Majengo, respectively, exceed the limit of 300 Bq/m^3 recommended by ICRP. This indicates that people living in the vicinity of Manyoni Uranium deposit are in danger of developing lung cancer and risks associated with leukemia and other cancers such as melanoma and cancers of the kidney and prostate. It is recommended that people should build their houses far away from the uranium deposits and these houses should be well ventilated.

Keywords: Indoor radon, concentrations, Uranium deposit, recommended limit

MEASUREMENT OF INDOOR, OUTDOOR AND UNDERFLOOR RADON CONCENTRATIONS IN A JAPANESE DWELLING

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A regulation of exposure from radon rises to an important issue due to increase in cancer risk under a residential radon level. World Health Organization also proposed 100 Bq m^{-3} of a reference level to regulate. In a Japanese dwelling, radon concentration at this level or above can be seen since a national survey revealed that residential radon concentration follows a log-normal distribution. A typical dwelling is composed of living rooms and underfloor space. The underfloor space touches directly to ground surface at which radon exhales, so that accumulated radon in the underfloor space may rise radon concentration in the living rooms due to infiltration through small pathways in floor board. Then, in this study, radon concentrations in the living room, underfloor space and outdoor were measured to investigate the connection among them. In addition, underfloor fans were equipped to examine radon mitigation.

The measurements were made in a typical dwelling in Japan which is a two-story wooden dwelling located in Gifu Prefecture. They were composed of radon concentration and environmental conditions (e.g., air temperature, relative humidity, and air pressure) in the living room, underfloor space and outdoor by using AlphaGUARD PQ2000Pro (Genitron Instruments, GmbH, Germany). For examining radon mitigation, two commercially available fans V-09FF3 (Mitsubishi Electric Corporation, Japan) were equipped to exhaust underfloor air.

Radon concentration in the living space was positively correlated with that in outdoor air (r^2 = 0.47-0.82). The similar correlation was found between the indoor and underfloor radon concentration although determination coefficient varied in a range of 0.24 and 0.72. Multiple regression analysis indicates that about 70% of outdoor radon entered into the living room and infiltration is nearly constant throughout the year. In addition, infiltration of underfloor radon into the living room followed a seasonal variation with maximum in winter and minimum in late summer. The high infiltration rate in winter may be caused by a chimney effect. We further investigated reduction efficiency of fan exhaust system in underfloor radon concentration. In summer, radon concentration was reduced by up to 50%, but, in winter, it was by only 20%. This is opposite to the trend of infiltration rate of underfloor radon. These imply that underfloor fan exhaust system is not effective against reduction of indoor radon concentration in the surveyed dwelling.

SETTING UP A CALIBRATION SYSTEM FOR DETERMINATION OF DISSOLVED RADON IN WATER USING SSNTDS

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Solid state nuclear track detectors (SSNTD) are commonly used for long-term indoor/outdoor radon measurements. A prototype passive integrating radon-in-water chamber based on the diffusion principle and using etch track detectors has been developed for measurement of the radon concentration in surface/drinking water and a system has been set up to calibrate it.

The measuring method is based on radon emanation from water into a floating chamber so that the inside Lexan polycarbonate detector are exposed to accumulated radon during the experiment. This approach is in particular advantageous if large water bodies with low radon concentration; e.g. rivers and lakes, or large scale monitoring; e.g. drinking water in a city, would be subject of investigation.

The calibration system principally consists of two water vessels and a flow-through radon standard source. This method generates the radon-in-water standard solutions with various radon concentrations applicable for calibration of continuous long-term radon-in-water measurement systems. Some important parameters which may effect on calibration characteristics, e.g. the effect of radon-in-air flow rate bubbled through the water to attain the state of equilibrium, were investigated.

The main objectives of the present work are: 1) to develop and optimize a straightforward and easy-to-handle experimental setup for the on-site determination of radon-in-water concentrations that allows the assessment of radon in surface/drinking water for large scale monitoring, and, 2) to apply a low running cost calibration system which is perfect for calibration and quality control of instruments and measuring methods.

The detection limit of the method depends on the exposure time, so that longer measuring time have the advantage to ensure a lower statistical error and improvement of detection limit.

The results show that the calibration factor is equal to 125.66 ($mBql^{-1}$).($track^{-1}cm^2$).(day) and the detection limit is about 0.096 Bql^{-1} for exposure time of 30 days.

RADON IN UNDERGROUND WATERS AS A NATURAL ANALOGUE TO STUDY THE ESCAPE OF CO2 IN GEOLOGICAL REPOSITORIES

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A subject of very great social interest is the climate change produced by the accumulation in the atmosphere of gases producing a global heating through the known greenhouse effect. In order to diminish the concentration of these gases, several global actions have been proposed by international organizations and treatises. In this scenario, one of the actions having an important mitigation effect should be the CO_2 sequestration and the deep geological storing in natural caves. Several research projects for the separation of CO_2 in pre-combustion and for the capture of this gas in oxy-combustion will be performed in two pilot plants in Spain. A storing repository will be necessary. For this, geological formations at about some hundred meters deep could be the solution for the storing of CO_2. Studies for determining the best sites to perform this are nowadays being made. In this context, studies of natural analogues of escape represent an indispensable tool.

Many man-made perforations were performed in the past for oil search, mining or geological research, or exploitation of underground waters. Some of these pits are now being used (mostly for irrigation purposes or spa resorts) while other were simply abandoned, but they can be used for the study of variables indicating the behavior of gases as natural analogues of escape of CO_2. In this way, natural radon can be considered as an analogue of CO_2 due to its inert gaseous behavior. In particular, ^{222}Rn is easily determined in environment using simple techniques in the laboratory.

This work shows the results obtained from the measurements of ^{222}Rn concentrations as natural analogue escapes in underground waters of Spain. The measurements were performed in aquifers selected by their characteristics to be possible sites considered as carbon dioxide repositories. To evaluate the activity ratio between ^{222}Rn with its progenitor ^{226}Ra and to detect possible disequilibria, this last radionuclide was also determined. In some few more interesting cases, isotopic uranium analyses were also made.

ESTIMATION OF EXTERNAL AND INTERNAL DOSES RESULTING FROM THE USE OF ARTIFICIAL RADON SPA SOURCES

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Recently, artificial-radon spa sources are sold for household bathtub use. These sources include high radium concentrations and it may give a radiation exposure to the users. In this study, five types of the artificial-radon spa sources were collected and dose estimations of the radon emitted from the five samples have been performed. The samples were enclosed in a cylindrical polypropylene container of 48 mmϕ × 55 mm after drying for 24 h at 105 °C. The prepared sample was left for 40 days to allow radioactive equilibrium to be reached between ^{226}Ra and ^{222}Rn. ^{226}Ra activity concentration was measured using High-Purity Germanium detector and measurement time was set as 80,000 s. ^{226}Ra activity concentrations of each sample were evaluated to be about 3,000 Bq/kg dry. The external dose by using an artificial-radon spa source was calculated by the following equation:

$$D_t = D_a \cdot \left(\frac{L_1}{L_2}\right)^2 \cdot \frac{\mu_a}{\mu_w} \cdot \frac{(\mu_{en})_t}{(\mu_{en})_w} \qquad (1)$$

Where, D_a is absorbed dose rate in air from the sample surface, L_1 is distance between sample surface and detector surface (1 cm), L_2 is distance between sample surface and genital gland (50 cm), μ is mass attenuation coefficient (*a*: air, *w*: water) and μ_{en} is mass energy absorbed coefficient (*t*: tissue, *w*: water). When people use these samples in the bathtub water, the absorbed dose received by the genital gland has been estimated to be 0.31-0.49 nGy. In this case, the equivalent dose to the genital gland was estimated to be 0.03-0.04 nSv. The internal dose from inhalation of exhaled radon from water surface was calculated by the following equation:

$$D = K \cdot T \cdot F \cdot Q \qquad (2)$$

Where, K is dose conversion factor (9×10^{-6} mSv/(Bq h m^{-3})), T is dwelling time (30 min), F is equilibrium factor (0.33) and Q: radon concentration (20 Bq/m^3). The effective dose from ininhalation per bathing has been estimated to be 0.03 μSv. If people drink 500-mL of water with radon concentration (18.5 Bq/L) every day, the internal dose from intake was calculated by the following equation:

$$D_W = K_W \cdot W \cdot Q_W \qquad (3)$$

Where, K_W is dose conversion factor (3.5×10^{-6} mSv/Bq), W is water intake per year (182.5 L/y) and Q is radon concentration in water. The annual effective dose has been estimated to be 12 μSv. The external and internal dose from the artificial-radon spa source estimated in this study were much smaller than the annual average value, which is 0.46 mSv, from radon in Japanese houses. Therefore, health effects from the artificial-radon spa source were negligible.

STATUS OF THE EUROPEAN ATLAS OF NATURAL RADIATION

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According to the EURATOM Treaty, it is the mission of the Joint Research Centre of the European Commission to collect, process, evaluate and present data on environmental radioactivity. In 2006 the JRC started the project of the "Atlas of Natural Radiation", in order to give an overview of the geographic distribution of sources of, and exposures to natural radiation. As first task a map of indoor radon concentration was tackled, since in most cases this is the most important contribution to exposure, and since it could be expected that data collection would take quite some time, because Rn surveys are very differently advanced between European countries. We show the latest status of this map.

A technically more ambitious map proved the one of the geogenic Rn potential (RP), due to heterogeneity of data sources across Europe and the need to develop models for estimating a harmonized quantity which adequately measures or classifies the RP. Further maps currently in the making are the ones of secondary cosmic radiation, of terrestrial gamma radiation and of the concentrations of the elements U, Th and K which are its source. We show the progress of some of these maps. The wealth of data collected in course of the "Atlas" project also enables statistical insights into the spatial distribution properties of the quantities for which we shall give examples.

PROBABILISTIC MAPPING OF THE GEOGENIC RADON POTENTIAL IN GERMANY

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The geogenic Rn potential (RP) is conceptualized to quantify what "Earth delivers" in terms of Rn. The RP indicates the hazard or potential risk at a location or as mean over an area, which can arise due to indoor Rn in a building, originating from geogenic Rn, and depending on its physical characteristic regarding Rn infiltration and accumulation. In geogenic Rn prone areas (RPA) which are ones with RP elevated after given criteria, the probability of encountering elevated indoor Rn concentrations is also elevated, again depending on house characteristics.

In Germany, the RP is estimated from Rn concentration in soil air and soil permeability, with geology as auxiliary categorical predictor. The hazard level is "calibrated" by relating the RP to indoor Rn concentrations in standardized types of dwellings, which by applying "hazard thresholds" leads to delineations of RPAs. The purpose of identifying RPAs is more efficient allocation of resources to intensified surveying, remediation and possibly implementation of building codes. It is also part of the national "Rn action plan" required by the new EU Basic Safety Standards.

We present an outline of methodology and show RP and RPA maps generated with it. Also problems and sources of uncertainty are addressed which have their origin on different conceptual levels, from geological classification uncertainty, sparseness of data, to uncertainty inherent to the statistical nature of models, and ways how they can be dealt with.

ESTIMATING THE RELATION BETWEEN RADON CONCENTRATIONS IN DWELLINGS AND SCHOOLS; ON THE EXAMPLE OF DATA FROM THE BALKAN REGION, SOUTH EAST EUROPE

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Given its relevance as hazard to human health, today almost unanimously accepted, indoor Rn is increasingly subject to regulation with the purpose of reducing the risk. While so far, investigations were mostly focused on domestic indoor Rn, attention has been extended to working environments, as people spend good (or bad) part of their life in offices, schools, shops, factories and other workplaces. In the recently issued European Basic Safety Standards (BSS 2014) the same maximum reference levels for indoor Rn concentration, long-term mean 300 Bq/m³, were therefore set for dwellings and workplaces. Many national and regional indoor surveys exist for dwellings, but only a few for schools and kindergartens and little for other workplaces. In particular schools are given increasing attention because they are workplaces for students and teachers alike, and avoiding unnecessary risk to children is naturally seen as an especially important objective.

It must be assumed that buildings on top of a ground with the same radon potential, but with different building characteristics and usage patterns, as is typically the case for dwellings and schools, have systematically different indoor Rn concentrations. Although this is well accepted, little is known about how these differences can be quantified, and what their extent is.

We show on indoor Rn datasets of schools and dwellings from several regions in South-East Europe how such relations can be estimated and give results. These can be used for identifying regions in which one may decide to allocate resources preferentially for intensified surveys or mitigation or remediation activity, specifically targeted to a type of indoor environment.

PRELIMINARY MEASUREMENTS OF INDOOR RADON AND THORON CONCENTRATIONS IN HIGH BACKGROUND RADIATION AREA OF KERALA, INDIA

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This paper describes preliminary results based on short-term measurements of indoor radon and thoron concentrations in high background radiation area of Kerala, India. As a result of 17 houses selected from the study area, the mean indoor radon concentrations in all houses were less than 20Bq m-3, which was less than the arithmetic mean in the world. It was observed that there were the houses with the thoron concentrations more than 100 Bq m^{-3}. The preliminary investigation showed that the thoron concentration was higher than radon concentration in most houses of the study area. It is possible that the dose contribution due to the inhalation of thoron and its progeny is important. Additionally, this finding implies that a radon and thoron discriminative measurement is necessary for an accurate measurement of both gases.

AN INTERCOMPARISON FOR THORON GAS ACTIVITY CONCENTRATION MEASUREMENTS

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An intercomparison experiment for active devices of thoron gas activity measurements was carried out using a ^{220}Rn chamber of National Institute of Radiological Sciences with the participation of eleven detection monitors from nine laboratories. The detection monitors were based on an electrostatic collection monitors with a solid state alpha detector and eight out of all detection monitors were from the same manufacture. As a result, the thoron concentrations depended on each detection monitor even if the detection monitors from same manufactures. In order to resolve such questions, the factors that affect the thoron detection for the detection monitor was investigated. As a result, it was found that the thoron detection was dependent on the instrumental detection response to thoron and decay of thoron gas during traveling in the sampling tube and detection chamber of the detection monitor. Thus the results obtained in this study show that it is necessary to make a periodical calibration, and consequently, maintain a quality level of thoron measurements.

DETERMINATION OF RADON CONVERSION FACTOR FOR EXHAUST MONITOR AT RADIOISOTOPE INSTITUTE

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Throughout Japan, many radioisotope institutes are using exhaust monitors with ionization chambers to determine if radionuclides leak into the air. Previously, we reported that some of the exhaust monitors recorded the variations in atmospheric radon (^{222}Rn) concentration [1]. However, since the exhaust monitors cannot be transferred, their radon conversion factor was not evaluated in the National Institute of Radiological Sciences (NIRS) radon chamber [2]. Our previous study determined the radon calibration factor and the minimum detectable activity of 0.33 Bq m^{-3} from the comparison between the AlphaGUARD and the exhaust monitor [1]. The sensitivity of the AlphaGUARD [3] was lower than that of the exhaust monitor. In this study, we determined the radon calibration factor from the comparison between the PMT-TEL and the exhaust monitor. The PMT-TEL [4] with ZnS(Ag) scintillator has higher sensitivity than the exhaust monitor. It is particularly suitable to trace typical outdoor radon concentrations. The radon conversion factor of the PMT-TEL, which can be transferred, was obtained in the NIRS radon chamber. The aim of this study is to determine a more accurate method in order to calculate the radon conversion factor of exhaust monitors. Moreover, by performing simultaneous measurements with the PMT-TEL (potable monitor), we are able to study the condition in which an exhaust monitor (a fixed monitor) can observe representative atmospheric radon concentrations around a certain area.

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NATURAL RADIOACTIVITY AND RADON EXHALATION RATE IN MAN-MADE TILES USED AS BUILDING MATERIALS IN JAPAN

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Some building materials contain relatively high concentrations of natural radionuclides (uranium and thorium series). In some cases, houses employing such building materials have enhanced radiation and radioactivity levels. It is possible that gamma ray dose rate in indoor environment is enhanced and that radon exhaled from the natural radionuclides accumulates in indoor air. European Commission recommends “activity concentration index” for the purpose of protection against gamma rays emitted from building materials. In the present study, frequently-used building materials (man-made tiles) were collected from a company. Natural radionuclide concentrations and radon exhalation rates were measured. Man-made tiles were also measured before and after baking. These parameters changed before and after the baking. In particular, radon exhalation rates were significantly reduced after baking. This could be because pore space existed in the materials was reduced by baking and the number of radon atoms emanated into the pore space was reduced. More detailed results will be presented at the conference.

STUDIES OF THE RADON CONCENTRATION IN WATER FROM QENA, EGYPT

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Water contains, among other components, soluble radon gas. Water sources in Qena were not the subject of wide survey as regards the levels of natural radioactivity. Especially, the concentrations of radon have not been investigated there in terms of their possible negative health impact. Environmental water samples from different sites in Qena area, south of Egypt, have been collected and analyzed for radon concentration. The water physical and geochemical properties, parameters such as pH, conductivity and TDS were also measured. ^{222}Rn activity concentration values ranged from 0.06 to 18.35 Bq/l, with an average of 4.03 Bq/l. The Results were compared with local and worldwide studies. The human health risk from irradiation due to direct ingestion was assessed for different age groups.

INDOOR GAMMA DOSE RATE FROM RADON PROGENY IN THE SPANISH LABORATORY OF NATURAL RADIATION (LRN)

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In 2010, the Radon Group from the University of Cantabria (Spain), in agreement with ENUSA (Spanish National Uranium Company), set up the Laboratory of Natural Radioactivity (LNR) located in the uranium mine of Saelices el Chico (Salamanca, Spain). This environment/area provides high levels of natural radioactivity which make the LRN into a matchless place for testing a wide variety of instruments and detectors under realistic field conditions.

The radon concentrations vary up to two orders of magnitude in different rooms that are used as radon chambers. Such variations are related to changes in temperature and atmospheric pressure. By means of controlling these fluctuations it is possible to perform intercomparison exercises of measuring systems under modifying climatic conditions, and to approach a more realistic situation dealing with the measurement of radon in dwellings and workplaces. Additionally, the assessment of other magnitudes such as external gamma dose rate, radon in water and radon in soil make the LNR suitable for intercomparisons of measuring systems of those parameters. Until now, two international intercomparison exercises have been carried out with more than 40 participatory institutions and laboratories.

In this work, besides the general description of the LRN, we will show the up-to-date developments related with the experimental correlation found between indoor radon concentration and gamma dose rate coming from radon progenies.

PERFORMANCE TEST OF PORTABLE TYPE RADON CONCENTRATION MONITOR FOR WATER SAMPLE BASED ON THE LIQUID SCINTILLATION COUNTER MEASUREMENT

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Recently, radon (^{222}Rn) in ground water is used for the prediction of diastrophism as a radioactive tracer. On the other hand, radon concentration in drinking water is important from the viewpoint of internal exposure to an organ. Liquid scintillation counter (LSC) which has high counting efficiency and accuracy is generally used for an evaluation of radon concentration in water samples. However, the general LSC cannot be used for in-situ measurement. Moreover, both use and disposition of an organic solvent are necessity according to the regulation which was prescribed at each country. In this study, radon concentration in ground water sample was measured using the RAD7 and the AlphaGUARD which are well known as the versatile portable type system, and these values were compared with the result of LSC in order to discuss on the possibility as a substitute of the LSC. Ground water samples were collected at university campus in Kobe City, Japan. The collected samples were measured using the RAD7, the AlphaGUARD and the LSC. The calibration factors, measurement accuracies and the minimum detectable radon concentrations to both the RAD7 and the AlphaGUARD were estimated based on the LSC measurement.

IMPACT OF ENERGY-SAVING MEASURES ON THE RADON CONCENTRATION IN DWELLINGS

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Due to rising energy costs, and prompted by the German ""Energiewende"" (abandonment of nuclear and coal-fired power plants), many people in Germany renovate or modernize their houses.

Filling and sealing the joints between various structures and materials or the installation of well insulated windows and doors can indeed cause a deterioration of indoor-air quality. Harmful gases from the building material or emitted from the underground may enrich the indoor-air.

In this context, a common and long known problem, is the strong relation between Radon-activity concentration in the indoor-air and the air-exchange rate. Radon is a radioactive gas, occurring in small amounts in every building. This gas, of natural origin, accrues in the underground and passes through the cellar to the living rooms where it causes a low radiation exposure to the residents.

The reduction of air-exchange rate, as a consequence of energy-saving measures, may result in an increase of the Radon-activity concentration in indoor-air. The radioactive decay of Radon in human lungs causes an increased exposure, which can ultimately result in health problems, such as lung cancer.

A study, funded by the Bundesamt fur Strahlenschutz (German Federal Office of Radiation Protection), was performed that assesses different approaches to energy-saving measures in buildings. The aim was a quantitative approach to determine the correlations of energetic renovation, air-exchange rate, and the Radon-level. The project comprises five inhabited buildings with various degrees of renovation. Each of the five houses is examined twice. Once before and once after the energy-saving measures.

The analysis of buildings includes Radon-, CO_2-, pressure-gradient measurements, and general information on the weather as well as volatile organic compounds VOC measurements.

Furthermore, using the “Blower Door” test, the status of the tightness of the evaluated building and the Radon-sources are determined. Additionally, thermographic camera recordings provide information about the exterior insulation and give more details on the results of the energy saving measures.

With the collected and collated data, a new model for various correlations, tracing underlying connections, and other patterns was developed and introduced.

MEASUREMENTS OF RADON AND THORON CONCENTRATIONS IN DWELLINGS OF NORTHERN RAJASTHAN USING SINGLE ENTRY PIN-HOLE DOSIMETER

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Radon gas is a significant health threat linked to thousands of preventable deaths each year. In present investigation, newly designed single entry face pin-hole dosimeter with LR-115 Solid State Nuclear Track Detector (SSNTD) has been used for the integrated passive measurements of residential radon and thoron in the environmental air of Northern Rajasthan, India. Indoor radon concentration in the dwellings of the study area was found to vary from 23 to 194 Bq m^{-3} with an average of 77 Bq m^{-3}, while thoron concentration ranges from 1 to 401 Bq m^{-3} with an average of 127 Bq m^{-3}. The annual effective dose due to the exposure to radon was found to vary from 0.58 to 4.89 mSv y^{-1} with an average of 1.95 mSv y^{-1}. However, the annual effective dose due to the exposure to thoron was found to vary from 0.003 to 1.12 mSv y^{-1} with an average of 0.36 mSv y^{-1}. The result shows that the average thoron concentration was higher than the average radon concentration in the dwellings of the study area. An effort has been made to find possible relationships of indoor radon and thoron concentrations with building construction materials and ventilation conditions of dwellings. Analysis of ventilation conditions reveal that the indoor radon and thoron concentrations were higher in poorly ventilated dwellings compared with the well-ventilated ones. Radon and thoron concentrations were found to be higher in mud type dwellings compared with the dwellings made of cement and marble.

CURRENT RADON REGULATION IN RUSSIA: STATE OF AFFAIRS AND NEW CHALLENGES

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Radon is the major contributor to the public exposure in Russia (nearly 60% of all natural radiation sources). The FLs (Public Radiation Protection, Public Sanitary Epidemiological Wellbeing) include the main legislative provisions of regulation. The main requirements and regulations established in national radiation safety standards (NRB-99/2010). According to the above regulatory documents the indoor concentration of radon and thoron progenies (in terms of equivalent equilibrium concentration (EEC) should not exceed 200 Bq/m^3 and 300 Bq/m^3, for dwellings and industrial buildings, respectively. In order to prevent potentially elevated radon levels in new buildings the regulatory system was developed during building construction and commissioning. It includes the mandatory provisions at different stages of building construction (radon flux density of the soil at the construction site, natural radionuclides in construction materials). Radon regulation at workplaces includes separate requirements for all industrial buildings and air quality of the working environment only for workplaces where radon exposure can be reasonably related to the operating process. For the purposes of radiation protection of the Russian population against radon, the national program took its rise in 1994 after approval of the purpose-oriented federal target program (FTP) «RADON» by the Government of the Russian Federation. At present, the main issues of this program are under implementation on the continuing basis under FTP «Nuclear and Radiation Safety Assurance». New challenges pronounced by WHO, ICRP, IAEA along with the high priority and complexity of radon problem for Russia need multiplex intersectoral and -regional efforts coordination. That is why, the radon national action plan is to be developed and this work began recently.

DOSE ESTIMATION FOR RESIDENTS IN HIGH BACKGRAOUND RADIATION AREAS. -CORRELATION BETWEEN RADON CONCENTRATION AND THORON CONCENTRATION-

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On March 11, 2011, an earthquake and tsunami caused serious damage to the Fukushima Daiichi Nuclear Power Plant (NPP) of Tokyo Electric Power Co (TEPCO). After this accident, many people concern about radiation risk, particularly chronic radiation exposure due to low dose rate radiation. However, the risk is not clear.

Therefore, the purpose of this study is to assess radiation dose in high background areas, Yangjiang in China, so as to understand biological effects on human being due to natural radiation exposure. For the internal exposure passive radon and thoron discriminative measurement techniques and thoron progeny measurement were introduced. These measurements were made at 60 house sites in Yangjiang, China.

The average radon concentration, thoron concentration, and thoron progeny concentration (EETC) were 124.1±77.7 Bq/m^3 (ranged from 26.5 to 476.2), 1247.1±1189.3Bq/m^3 (ranged from 64.9 to 3957.1), 7.6±9.1 Bq/m^3 (ranged from 0.59 to 36.2) respectively. When estimating the equilibrium factor of thoron, it was calculated to be 0.006, which was lower than the typical value presented in the UNSCEAR report. The thoron concentration is approximately ten times as high as that of radon. Compared to the radon concentration, thoron concentration varied very much. It seems that the large difference of thoron concentration may be derived from the building materials of each house. According to our investigation, the average radon concentration, thoron concentration, and thoron progeny concentration (EETC) were 6.1 ± 4.3Bq/m^3 (ranged from 1 to 21), 50±35Bq/m3 (ranged from 11 to 212), 2.2±1.5 Bq/m^3 (ranged from 0.4 to 8.0) respectively in Kerala, India. These data in Kerala,India are lower than those in Yangjiang,China.

FIRST RESULT: MITIGATION OF INDOOR THORON DECAY PRODUCTS BY AIR DOOR

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Increasing attention has been focused in the recent years on thoron (^{220}Rn) which can cause a remarkable exposure and threat to human health in some regions or working places worldwide. A variety of active methods like filtration, were studied for decreasing the thoron progeny as well as its inhalation dose. However, the unattached fraction of thoron decay products usually rise to different extent dependent on filtration rates in such active method. In fact, that is not always the case. In present study, a device called air door (power 37 W, air volume 330 m^3/h) which has not been previously reported for applying in the radiation protection field was intensively investigated for mitigating the thoron progeny hazard. The experimental results show that the air door is not only significantly decrease the attached thoron decay products concentration, it is also very effective in cutting down the unattached thoron decay products. The average *PAEC* of attached thoron decay products and unattached thoron decay products decreased by about 90% and 55%, respectively, when such air door was applied in an experimental clay house. The mechanism of the device for reducing the both states of thoron decay products was also illustrated. Since air door is widely used in industrial or commercial settings for helping to maintain heated or air conditioned air, this study suggests further application in domestic use or underground uranium mining sites in the case of high concentrations of thoron decay products, to protect the residents or workers from the exposure from the radioactive gas.

DISTRIBUTION OF RADON CONCENTRATIONS IN SPA WATER IN KYUSHU DISTRICT

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The authors measured radon concentration in hot-spring water at the several famous spring spots, such as Misasa spa (Tottori Prefecture), Masutomi spa (Yamanashi Prefecture), and Ikeda spa (Shimane Prefecture) by means of the Pico-rad system which used the liquid scintillation method. Although the high concentration points had been observed until now, in this study we discuss the concentration in a large area, Kyushu district which has many hot-springs resorts, such as Beppu, Ibusuki, Kirishima, and Aso. This research describes the result of having measured the radon concentration in spring water from 2010 to 2013 with the liquid scintillation method.

The radon concentration in spring water was evaluated by using the convenient and highly sensitive Pico-rad system. The 10 ml of spring water was mixed with the same amount of liquid scintillator (Opti-fluor) in a glass vial with 20 ml volume, and the vial was shaken for 15 seconds or more. Next, the vial was set in a liquid scintillation counter (Packard, TRI-CARB 2250CA Type), and counted for 100 minutes. The sampling points were about 100 places in Miyazaki, Ohita, Nagasaki, Kagoshima, Saga and Kumamoto Prefecture, and two sample of each place, the average value was made into the radon concentration of the place.

As a result, the radon concentration in spring water in Kyushu district was a comparatively low value except for one place in Fukuoka Prefecture. The average concentration of each prefecture until 2011 except Fukuoka Prefecture ranged from 1.8 Bq/L to 8.6 Bq/L. The concentration of the two sampling points in Fukuoka Prefecture was as high as an average of 74 Bq/L. The air absorbed dose rate in Fukuoka Prefecture is relative high because of the granite area. It is thought that the high radon concentration is due to high content of radium in soil.

ESTIMATION OF ANNUAL EFFECTIVE DOSE DUE TO RADON AND THORON CONCENTRATIONS IN MUD DWELLINGS OF MRIMA HILL, KENYA

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For the longest time, radioactivity in indoor air was attributed to radon given its relatively longer half-life. Thoron was presumed to decay within the building material shell, a likely scenario in compact building materials such as those used in most western countries. In rural Africa and Asia however, raw soil constitutes the main component of building materials. Being highly porous, such materials can act as important sources not only of radon but also thoron thus adding to the inhaled dose in these areas.

Mrima hill is one of the regions in Kenya with the highest levels of background radiation attributed mainly to ^{232}Th. The region has a rural setting and typically, soil serves as the main wall material of dwellings; the floor is usually left as bare earth. Discriminative measurements of radon and thoron concentration were carried out in the mud dwellings using twin CR-39 SSNTD. The effective dose (E) was then evaluated from the relation; E=CFQt, where C is the concentration of the isotope of interest, F the equivalent factor (0.4 for radon and 0.1 for thoron adopted from Yamada et. al., 2006), Q the dose conversion factor and t the indoor occupancy time (hours) per year (60% in Kenya).

Radon concentration varied from 16-56 Bq/m^3 with an average of 35±14 Bq/m^3 resulting in a mean effective dose of 0.67 mSv/y. All radon concentration measurements were below 200 Bq/m^3. Thoron concentration ranged from 132-1295 Bq/m^3 with an average of 652± 397 Bq/m^3. 65% of the measurements were above 300 Bq/m^3 with 25% being over 1000 Bq/m^3. The average effective dose due to thoron was estimated to be 13.70 mSv/y and is comparable to that reported in the cave dwellings of the Chinese loess plateau. Clearly, the contribution of thoron as a source of inhaled dose is significant.

ESTIMATION OF RADON EMANATION COEFFICIENT FOR REPRESENTATIVE SOILS IN OKINAWA, JAPAN

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Radon (^{222}Rn) emanation coefficients for the representative soils distributed in Okinawa-jima, a subtropical island of Japan that takes relatively high atmospheric radon concentration and high radon exhalation rate, have been estimated empirically. During the examination, soil samples were airtight sealed in accumulation chamber for 24 h. Then tha radon concentration (Bq m^{-3}) in the chamber was determined using Pylon AB-5 measuring system. Tha radon concentration in equilibrium condition (Bq m^{-3}) was calcurated by the measured radon concentration. The radon emanation coefficient was calculated by the radon concentration in equilibrium condition, gas phase volume (m^3), radium content of soil sample (Bq kg^{-1} dry) and soil sample weight (kg). To investigae the variable factor of the emanation coefficients, analyses of radioactive elements and grain size distributions have also been performed on the soils. In Okinawa, the soils are traditionally classified into three types, namly the dark red soils, the red and yellow soils and the residual regosols. Arithmetic means ± standard deviations of the coefficients for in dry and wet conditions were calculated to be 0.19 ± 0.7 and 0.28 ± 0.09, respectively. The dark red soils have peculiarly high coeffients of 0.26 for dry and 0.40 for wet conditions. The red and yellow soils and the residual regosols have relativery low coefficients of 0.15 - 0.16 for dry and 0.23 for wet conditions. The concentrations of ^{238}U series were estimated to be about 106 Bq kg^{-1} dry for the dark red soils, 41 Bq kg^{-1} dry for red and yellow soils and 22 Bq kg^{-1} dry for residual regosols. About the dark red soils, the content of clay is above 10 % highter than those of the other soils. Based on these results, the variation of the radon emanation coefficient is considered to be regulated mainly by the contents of ^{238}U series, clay and water in the soils.

SPATIAL DISTRIBUTION OF RADON AND PROGENY INSIDE A DWELLING AT MYSORE CITY, INDIA

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^{222}Rn a decay product of ^{226}Ra in the naturally occurring ^{238}U series is a radioactive inert gas and constitutes about half the radiation dose received by general population. The amount of radon that emitted from the earth's surface depends mainly on the amounts of ^{238}U, ^{232}Th and ^{226}Ra present in soil and also the on the nature of soil, its porosity and meteorological conditions. Indoor radon and its progeny concentration vary with ventilation condition, exhalation of radon from the floor, surface of wall and structure of the building. Radon and its short-lived decay products can be deposited in the lung tissues and give rise to higher radiation doses. Long time exposure of population to higher concentrations of radon and its progeny leads to occurrence of lung cancer and other pathological effects such as respiratory functional changes. The spatial distribution of radon and its short-lived decay products was systematically studied inside a dwelling at different co-ordinates and time scales. The results show that, radon concentration slightly decreases with increasing height from the floor and it becomes almost uniform beyond 1.0m. Highest radon concentration of 33.8 Bq.m^{-3} was observed at height 0.5 m above the floor and 0.5 m away from the wall. Lowest radon concentration observed was 10.6 Bq.m^{-3} at a height of 1.5m from the ground and 0.1 m away from the wall. The results show that, very close to the surface of the wall and the floor, radon progeny concentrations were low due to attachment on the surfaces.

STUDIES ON RADON IN SOIL GAS, RADON EXHALATION RATE FROM THE GROUND SURFACE AND RADON VERTICAL PROFILE IN THE ATMOSPHERE NEAR THE GROUND SURFACE AT MYSORE CITY, INDIA.

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Radon is formed in the decay chain of naturally occurring primordial radionuclides ^{238}U, ^{232}Th and ^{235}U present in the earth's crust. Radon is a radioactive noble gas and short-lived daughters of radon (^{218}Po, ^{214}Pb, ^{214}Bi and ^{214}Po) are electrically charged particles and are chemically reactive. After its formation in the earth crust, radon can slowly diffuse up into the atmosphere until it undergoes radioactive decay. The rate of radon diffusion depends on the geological factors such as porosity, temperature difference between top layers of soil, moisture content of the soil and permeability of soil; and meteorologi¬cal factors such as rainfall, wind, humidity and other environmental conditions. The vertical profile of the outdoor radon/thoron and their progeny concentrations is useful to study radon gas as a tracer in the atmosphere. The worldwide average of radon flux as 0.016 Bq m^{-2} s^{-1} and world average radon concentration outdoor is about 10 Bq m^{-3}. The concentrations of radon, thoron and their progeny in the atmosphere up to a height of 12m from the ground surface and in soil gas up to a depth of 1.5m are measured using LR-115 TYPE II Solid State Nuclear Track Detectors. Radon exhalation rate from the ground surface is measured using a radon accumulation chamber and Low Level Radon Detection System. All the measurements were carried out simultaneously near the department of studies in physics, university of Mysore, Mysore city (12^{o} N, 76^{o} E), India. The concentration of radon in soil gas increases with increase in depth. Radon exhalation rate show a good correlation with the temperature difference between different layers of the soil. Concentrations of radon in the outdoor environment are affected both by the rate of radon exhalation ground surface and also by atmospheric mixing phenomena. During the daytime solar heating tends to induce atmospheric turbulence, so that radon is readily transported to higher altitudes away from the ground. The vertical variations of radon/thoron and their progeny concentrations were observed to be decreasing up to about 5 m above the ground surface and then the concentrations are almost same with small fluctuations.

DETERMINATION OF THE LOCALITY OF THE DECAYED RADON ORIGINATED FROM MILL TAILINGS (UMTS) IN DIFFERENT LAYERS OF REMEDIATED URANIUM TAILING POND

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The surface of the uranium mines and mill tailings (UMTs) with elevated Ra-226 content is in possession of significant radon exhalation, can be reduced with different type and thickness of covering layers. The effectiveness of the overlay was investigated via the radon daughter elements in case of the waste rock dumps belong to the remediated uranium mine in Kővágőszőlős (Hungary). The locations of the radon retentivity and the dependency of them from meteorological parameters can be used in case of further remediation and operation processes of existing remediated sites as well.

In the present study the radon concentrations of soil gas were measured between 20-160 cm (in every 20 cm) with AlphaGUARD and Pylon AB5 type radon monitors. The obtained results and previous exhalation models present that the different layers do not contribute to the retentivity in equal measure. The radon concentrations have great seasonal variation. Due to that fact the long life radon daughter elements concentration can characterize the radon retentivity of the overlay.

Samples were taken from the entire vertical overlay. The Ra-226 and the Pb-210 concentration were investigated by HPGe gamma spectrometer. The Pb-210 concentration can originated from the natural Ra-226 content of the coverage, from the radon surplus flow up from the waste rock and near to the surface from the fall-out.

In order to get accurate Pb-210 results the Po-210 content was also determined with alpha-spectrometry.

On the basis of the obtained results the amount of the radon flow up originated from the waste rock reduced under 10% of the initial in the first covering layer between 150-110 cm. The Pb-210 surplus can be significantly detected in this layer. Furthermore slightly elevated Pb-210 content was measured in the upper 20 cm, presumably caused by the fall-out

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SIMULTANEOUS DETERMINATION OF RADON/THORON EXHALATION OF HEAT-TREATED RED MUD MIXED CLAY SAMPLES

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The harmful effect of Radon (Rn-222), Thoron (Rn-220) and their progenies is well-known. In case of indoor conditions the elevated Radon and Thoron levels can cause significant dose contribution for residents. The natural radionuclide content of the construction materials and the structure of their matrix have great effect on the radon and thoron exhalation capacity. Nowadays the possibility of industrial by-products is getting more and more actual can contain elevated radionuclide content.

In this study the effect of heat-treatment was surveyed on NORM origin red mud by-product mixed clay. The natural radionuclide content was determined with gamma spectrometry and the optimal mixing ratio was calculated according to I-index. It was found that 20% red mud is allowable to keep the criteria.

Homogenous spherical samples with 4-5 mm diameter were prepared to ensure conditions necessary to free exhalation. The heat-treatment was performed in different temperatures (100, 200, 400, 600, 1000°C) with the help of programmed, pre-heated kiln during 2 hours.

The Radon and Thoron exhalation were measured with widespread used ALPHAGUARD 2000 radon monitor connected to closed loop accumulation kit. It was found that the exhalation capacity reduced greatly as a result of heat-treatment. The initial (100°C treated) 41±5 $mBqkg^{-1}h^{-1}$ Radon exhalation reduced under 3±2 $mBqkg^{-1}h^{-1}$ in case of 1000°C treated, whilst the initial 34±5 $mBqkg^{-1}h^{-1}$ Thoron exhalation decreased under 6±2 $mBqkg^{-1}h^{-1}$. On the basis of the obtained results it can be clearly stated that the Radon and Thoron exhalation can be effectively reduced (under 10% of the initial) with the help of high temperature heat-treatment. Furthermore the risk originated from Radon and Thoron exhalation of building material can be reduced as well.

PREPARATION AND CHARACTERIZATION OF CERAMIC BASED THORON SOURCES FOR THORON CALIBRATION CHAMBER

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Surveys recently performed showed that the precise determination of thoron concentration is important for several reasons. During the long time surveys the application of active measuring devices is difficult or not possible. Instead of these the integral measuring devices, known as track detectors, are commonly used. However, the calibration of the detectors is important for the evaluation of the measurement data. For this purpose, a highly controllable calibration chamber is needed; however, several measurement technical problems occur owing to the short half-life of thoron. Recently, a thoron chamber was developed in the Institute of Radiochemistry and Radioecology, but the examinations performed up to now showed that the improvement of the chamber is needed for the more accurate operation.

The preliminary experiments proved that the thoron source presently available is appropriate for the examination of the radon measurement disturbing effect of thoron, but for the calibration the preparation of more thoron sources with different concentration levels and the examination of their parameters' effects on the chamber's properties are needed. The aim of this is to explore the correlations between the properties of the source's material and the thoron flux produced. This means a complex procedure which contains morphological characterisation (determination of specific surface area and pore size distribution) and thoron emanation and exhalation measurements as well.

In this work the preparation of 27 thoron sources has been carried out. Three types of ceramics with different morphological properties were used as a matrix material with three different thorium contents. Spheres were formed from the dollop and they were fired at different temperatures (200, 600, 900°C). The phase analysis of the samples was performed by powder X-ray diffraction method. The pore size distribution was determined by mercury penetration method. The thoron emanation was measured with accumulation chamber, the measured thoron emanation coefficient were from 0.34 ±0.03 to 7.69 ±0.13 %. Based on the results the preparation parameters of the thoron source optimized for the calibration procedure have been given.

ORAL PRESENTATIONS

THE ROLE OF FIRST-ORDER FERMI DIFFUSIVE SHOCK ACCELERATION IN GENERATING COSMIC-RAY FLUXES

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Cosmic rays and other high-energy particles of extraterrestrial origin are produced by first-order Fermi diffusive shock acceleration in a plasma. This is an efficient form of acceleration, accelerating particles up to eV, the point where they interact with the cosmic microwave background (CMB), the Greisen-Zatsepin-Kuz'min (GZK). First-order Fermi shock acceleration is due to a supersonic shock with an index (or logarithmic slope) dependent on the Mach number of the shock-induced power-law spectrum.

The local all-particle interstellar cosmic-ray spectrum can be obtained from the solution of a Fredholm integral equation in rigidity, yielding both the "knee" and the "ankle" of the primary spectrum. The effect of the maximum galactic acceleration mechanism at high energies near the ankle is to increase the relative number of heavy nuclei relative to protons. Multiple cutoffs of heavier nuclei due to interactions with the CMB have the opposite effect just below the GZK cutoff, resulting in fluxes enriched in protons.

Earthward-directed supersonic coronal mass ejections are responsible for the great bulk of high-energy solar-particle events because of diffusive shock acceleration in the heliosphere.

THE POSSIBLE ROLE OF COSMIC RAY EXTENSIVE AIR SHOWERS IN THE INITIATION OF LIGHTNING

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Despite the fact that some version of the Relativistic Runaway Electron Avalanche (RREA) model is considered by many to be the most likely explanation of lightning initiation, there have been few efforts at experimental validation of this model. We are attempting to experimentally validate the RREA model by correlating time- and location-resolved lightning initiation data from the Oklahoma Lightning Mapping Array (OKLMA) with time- and location-resolved cosmic ray muon count rate data. Secondary cosmic ray muons are used as a proxy for relativistic seed electrons produced in cosmic ray extensive air showers (CREAS) since few secondary cosmic ray electrons make it to the ground before ranging out. An array of four ground-based cosmic ray muon detectors have been designed, fabricated, and deployed in the shape of a 200 m square within the central area of coverage of the OKLMA. Each detector consists of a pair of plastic scintillators separated by a 3 cm layer of Pb in order to discriminate between relativistic muons and lower energy electrons and g-rays, including those of terrestrial origin. Each detector measures the muon count rate with sub-millisecond resolution and data from the four detectors are combined to identify large CREAS. Data from the cosmic ray muon detectors obtained while thunderstorms pass over the array are then compared to OKLMA data. We present preliminary results from this experiment and describe how the cosmic ray muon detector array can be expanded to obtain higher resolution data over a wider area of coverage.

EXTREME SOLAR EVENTS MEASURED ONBOARD AIRCRAFT IN PERIOD 2001 – 2014

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Extreme solar events (ESEs) like coronal mass ejections (CMEs) and solar particle events (SPEs) can rapidly change the intensity, composition and energy distribution of cosmic radiation in the Earth's atmosphere. Computer codes used for calculation of aircrew doses don't consider these changes routinely. Measurements onboard aircraft are therefore important for estimation of real doses and verification of computer codes.

ESEs can result into (i) the increased dose and intensity of cosmic radiation detected on Earth's ground – such event is called the Ground Level Enhancement (GLE), or (ii) decreased dose and intensity of cosmic radiation on ground – so called Forbush decrease (FD).

In this paper, we present analysis of our measurements with the silicon spectrometer Liulin onboard aircraft during SPEs and comparison with the neutron monitor records. In the studied period from 2001 to 2014, one GLE (the GLE 60 occurred on April, 15th 2001) and several FDs were detected onboard aircraft. We expressed the changes caused by ESE onboard aircraft via comparison of the monitored quantities during ESE and during normal solar conditions: (i) the absorbed dose in silicon separately for low LET and high LET components, (ii) ambient dose equivalent $H^*(10)$, and (iii) spectra of energy deposited in silicon. We observed a good correlation between the changes registered by Liulin onboard aircraft and those registered by neutron monitors on ground. The dose equivalent measured with Liulin was about 55% higher for the flight during the GLE 60 than for normal conditions. Decreases measured by Liulin during FDs fluctuated between 5% and 26%; they differ based on the FD intensity, geographical location and flight altitude but generally were higher than decreases measured by neutron monitors on ground. Radiation quality expressed via energy deposition spectra showed higher contribution of high LET component during FDs.

RESPONSE OF COSMIC RADIATION ON THE READOUT OF GAMMA DOSE RATE METERS

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For an accurate evaluation of the external public exposure, both the terrestrial gamma radiation and cosmic radiation are required. As it is relatively difficult to monitor the cosmic radiation directly, the dose rates of cosmic radiation are usually estimated by the empirical formula. However, the effects of cosmic radiation on the readout of different types of gamma dose rate meters are still needed in order to accurately quantify the terrestrial gamma radiation.

In this study, a total of 8 models of gamma dose rate meters were tested for studying the effect of cosmic radiation on the readout at 6 different sites with different geographic and geomagnetic latitudes in China. All of the measurements were performed on deep lakes, and the distances between the measuring points and the nearest lands were above 1000 m. During the measurements, ^{222}Rn concentrations were also measured with the AlphaGuard®. Among the 6 sites, the readout of the 8 sets of dose rate meters ranged from 10.3 nGy•h^{-1} to 77.4 nGy•h^{-1}, while the dose rates of cosmic radiation were estimated to range from 28.3 nGy•h^{-1} to 65.6 nGy•h^{-1} based on the empirical formula, and the effects of ^{222}Rn and its progeny on the readout could be neglected. Compared the readout with the estimated values of cosmic radiation, it was found that the readout of dosimeters with high-pressure ionizing chambers was generally higher, while the readout of survey meters with scintillation detectors was always lower. Furthermore, it was also found that the relative variance between the readout and the estimated value was significantly different even though for the same type of detector. The above results imply that the response of cosmic radiation on the readout of gamma dose rate meters should be calibrated for an accurate measurement of terrestrial gamma radiation, or for estimating the cosmic radiation.

Key words: Gamma dose rate, Cosmic radiation, terrestrial radiation, ^{222}Rn.

POSTER PRESENTATIONS

VERTICAL DISTRIBUTION OF GAMMA-RAY DOSE RATES IN THE WATER OF A BRACKISH LAKE IN AOMORI PREFECTURE, JAPAN

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Seasonal environmental γ-ray dose rates were measured at various depths in the water of Lake Obuchi, a brackish lake in Aomori Prefecture, Japan, during 2011–2013 to assess the background external radiation dose for aquatic biota living in the lake. The lake (surface area, 3.7 km^2; maximum depth, 4.5 m) is adjacent to Japan's first commercial nuclear fuel reprocessing plant, which is scheduled to begin operation in October 2014. The background radiation data obtained in this study will be used as reference values for the dose rates from radionuclides discharged from the plant.

Three points in the lake and one point in its outflow (the Obuchi River) were selected as observation points, and γ-ray dose rates were measured with glass dosemeters in watertight cases. No nuclear fuel was being cut or processed in the plant during the observation period.

The mean environmental γ-ray dose rate was about 27 nGy h^{-1} in the surface water (0 m depth) at three points in the lake, and this rate is similar to the external dose rate due to cosmic rays in Aomori Prefecture. The γ-ray dose rate decreased exponentially with increasing water depth until a depth of 0.5 m above the bottom sediment, where the rate then began to increase with depth because of γ-rays from the sediment. In the Obuchi River, the dose rate at a depth of 0.4 m (0.1 m above the fluvial sediment) was about 30 nGy h^{-1}, which is slightly higher than the rate at the lake surface. Although ^{40}K in brackish lake water can affect the γ-ray dose rate in the water, the contribution of ^{40}K is small; it has been evaluated to be 1 nSv h^{-1} even in seawater.

Our results indicate that cosmic rays constitute a major source of external radiation exposure to floating aquatic biota, including fish. Demersal fish and benthos are also exposed to additional radiation due to γ-ray-emitting radionuclides in the bottom sediment.

This study was performed under a contract with the government of Aomori Prefecture, Japan.

CONTINUOUS MONITORING OF COSMIC-RAY INDUCED NEUTRONS AT THE SUMMIT OF MT. FUJI

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To improve the reliability of the evaluation of aircrew doses and to prepare to the evaluation of additional dose caused by the ground level event which rarely occurs following a solar flare outbreak, we have started to construct a radiation monitoring system at Mt. Fuji automated weather station founded on the summit of Mt. Fuji (altitude of 3776 m) from 2010. The radiation monitoring system consists of a moderator-type neutron rem meter having a wide energy range from 25 meV to 5 GeV, a controller unit, a long-distance wireless local area network (WLAN) router, a directional Uda-Yagi antenna and battery power units. The reason why we have selected to monitor cosmic-ray induced neutrons (cosmic neutrons) is that those are the main contributor to cosmic radiation exposure. A long-distance WLAN receiving system connecting the Internet is installed in Fuji observatory of Nagoya University in the foot area of the Mt. Fuji. The distance between the Mt. Fuji automated weather station and the Fuji observatory is about 13 km. The radiation monitoring system connects the Internet via the long-distance WLAN receiving system. The measured neutron count rates in count per hour at the Mt. Fuji automated weather station from August 22, 2013 to March 12, 2014 changed between 100 and 150 with approximately 20% of variance. Negative correlation was seen between the neutron count rate and the atmospheric pressure. We think that this is because as the atmospheric pressure is higher the atmospheric thickness is thicker, and the cosmic neutrons are reduced in atmosphere more. At present, the atmospheric pressure seems to have a dominant affect to a change of the neutron count rate. Then, we intend to investigate other factors which may be buried among atmospheric pressure influence.

ORAL PRESENTATIONS

NATURAL RADIATION IN THE GEOLOGICAL ANOMALY OF POÇOS DE CALDAS PLATEAU, BRAZIL

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The Poços de Caldas anomaly has been subject to attention of geologists for many years. It is an about circular shaped structure of several 10 km diameter, elevated a few 100 m above the surrounding region, formed by an alkaline intrusion including volcanic activity. Within this geological unit there are geochemical anomalies, such as a uranium deposit which has been exploited by a U mine (now under remediation), and the notable Th and RE anomaly Morro de Ferro where ambient dose rate up to several 10 μSv/h is encountered. Several small cities are located in the otherwise rural region with population together a few 100,000.

We give an overview on the geological setting and present data of radiometric surveys which have been performed over the years. In the last years they have been intensified and include detailed surveys of ambient dose rate, indoor Rn, geochemical quantities and, since recently, Rn in soil. In a few cases largely increased indoor Rn concentrations above 1000 Bq/m³ were found. Also epidemiological data of cancer mortality are available which however require very considerate and restrained interpretation. We shall also give a summary of the results of the Second Brazilian Rn Seminary, which took place in Poços de Caldas in May 2014 (after the deadline for this abstract), in which discussion of radiation in this remarkable area also was an important part.

A HIGH NATURAL RADIATION AREA IN KAOTAN HOT SPRING OF THA-CHANG DISTRICT, SURAT THANI PROVINCE, THAILAND AND ITS RELATION TO GEOLOGICAL FORMATIONS

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Natural radioactivity in Kaotan hot spring, Tha Chang District, Surat Thani Province, southern Thailand is investigated. A high radioactive Cretaceous granite in the western highland nearby is supposed to be the source of natural radionuclides in this area while an active fault, the Klong Marui fault has been expected to pass over the area. Gamma ray dose survey indicated a possible high radiation risk for this area. Rock, soil and hot spring mud samples were then collected and analyzed by a low background γ-ray spectrometer. The activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in samples were found to vary from 469 – 657 (mean = 563), 12 – 52 (32), 24 – 153 (88) Bq kg^{-1}, respectively, for limestone samples; 151 – 10201 (3889), 45 – 408 (157) and 40 – 571 (228) Bq kg^{-1}, respectively, for soil samples; and 372 – 139092 (17885), 22 – 596 (127) and 76 – 616 (221) Bq kg-1, respectively, for hot spring mud samples. The absorbed gamma dose rate in air of this area varied from 183 to 64640 (6461) nGy h^{-1}, which was 115 times higher than the world average value of 56 nGy h^{-1}. The external annual effective dose rate was estimated to be 0.225 to 79 (7.92) mSv y^{-1}, with median value of 2.8 mSv y^{-1}. The 25th percentile of external annual effective dose rate was 1.2 mSv y^{-1}, and the 75th percentile was 6 mSv y^{-1}. In conclusion, this hot spring area can be reasonably classified as a high natural radiation background area, due to the high concentration of radium in the rocks, soils and muds. The source of radium in this area is supposed to relate to the fault fluids enriched in radium and co-precipitation with calcium in the carbonate terrain.

MEASURING RADON CONCENTRATION AND ESTIMATING DOSE IN TURIST CAVES

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Underground caves are especially critical places for ^{222}Rn exposition because generally they consist of systems with no ventilation. The problem is that people working in these places are being continuously subjected to exposure to ^{222}Rn and its daughters. Existing legislation and recommendations concerning indoor ^{222}Rn exposure may be applicable.

In a survey on radiation in workplaces in the Extremadura Region (Spain), very high levels of indoor ^{222}Rn concentrations were measured in some caves promoted for tourism. Two places have caves open regularly to visits: Castañar de Ibor, and Fuentes de León.

The Castañar de Ibor cave, located in the north-eastern part of the region, is a karst formation with calcite and aragonite speleothems. This cave is a labyrinthine cavity about 2135 m in length, with a nearly horizontal development at 31 m mean depth below ground, divided into several chambers. The interior temperature is stable at about 17°C all year, and the relative humidity is near saturation point (about 95%).

The second system of caves is located near the village of Fuentes de León, in the southern part of the region. This system is formed by a group of four separate caves named Cave of the Horse (with groundwater in the lower part), Cave of Masero (with calcite formations), Cave of the Posts (with deposits of archaeological interest), and Cave of the Water (closed to the public due to landslips and the conservation of protected wildlife). The first three caves are commonly the destinations of school visits, having direct access from the surface, and being of no great depth or length. Humidity inside is high (near the saturation point), and temperature is variable due to external influences.

The aim of the present work was thus to characterize radiologically the main caves in this region to determine whether these places present adequate conditions for workers. Results obtained were thus used for the estimation of the dose received by workers, or for the consideration of possible hazards for visitors.

ANALYSIS OF INTERNAL EXPOSURE ASSOCIATED WITH CONSUMPTION OF CROPS AND GROUNDWATER FROM THE HIGH BACKGROUND RADIATION AREA OF MRIMA HILL, KENYA

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Mrima hill in Kwale County is one of the regions in Kenya with the highest levels of background radiation. Small-scale farming is the mainstay of the economy with cassava as the main cash as well as food crop while hand-dug wells serve as the source of water for the residents. The objective of this research was to determine the radiation exposure associated with consumption of cassava (tubers and leaves) and well water in the region. Content of ^{226}Ra, ^{232}Th and ^{40}K were analysed in samples using the HPGe detector and the exposures calculated using appropriate conversion factors.

Over 70 % of cassava tubers and leaves had detectable amounts ^{226}Ra with average concentrations of 60±5 Bq/kg and 141±11 Bq/kg respectively. ^{232}Th, with an average concentration of 35.3±61.5 Bq/kg was detected in 28 % of the tubers; it was not detected in the leaves. 37 % and 7 % of water samples detected for ^{226}Ra and ^{232}Th with average concentrations of 4.3±0.3 Bq/kg and 2.0±0.1 Bq/kg respectively. ^{40}K was present in all samples in averages of 842±539 Bq/kg, 1708±552 Bq/kg and 91.4 Bq/kg in cassava tubers, leaves and water respectively. The annual effective dose rates from cassava tubers, cassava leaves and groundwater consumption were calculated as 2.4 mSv/y, 3.8 mSv/y and 1.7 mSv/y respectively.

ESTIMATION OF EXTERNAL DOSE BY CAR-BORNE SURVEY IN KERALA, INDIA

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A car-borne survey which used a 3" × 3" NaI(Tl) scintillation spectrometer (EMF-211, MEF Japan Co., Japan) was carried out in Kerala, India for the estimation of external dose during the period from September 23th to 27th, 2013. The survey routes were selected from a total of 12 Panchayats in Karunagapally Taluk which were classified into the high background radiation area, the middle level area and the controlled area. Measurements of the counts inside a car were carried out every 30 seconds. Latitude and longitude at each measurement point were measured with a global positioning system simultaneously during a car-borne survey. The shielding factor of car body was estimated by making measurements inside and outside of the car at 34 points and corrected with inside count rates. The shielding factor was evaluated to be 1.47. Measurements of gamma-ray pulse height distribution were carried out 1 m above the ground surface at 35 points in Karunagapally Taluk for the evaluation of conversion factor from the count rate to the air kerma rate. Counting time was referred to the dose rate measured by pocket survey meter (PDR-111, Hitachi-Aloka Co., Japan), and it was set as 300 to 900 sec. The conversion factor was evaluated to be 0.00234 (nGy/h/cpm). The maximum value of annual effective dose in Karunagapally Taluk was observed around the coastal area, and this value was estimated to be 14 mSv/y. Distribution map of the air kerma rate was drawn using Generic Mapping Tools (GMT). Heterogeneous distribution of air kerma rate was shown in this map.

DOSE ASSESSMENT OF INHABITANTS OF HOMA MOUNTAIN AREA, HOMA BAY COUNTY IN KENYA DUE TO ELEVATED NATURAL RADIOACTIVITY

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Rock and soil samples collected from Mount Homa area located in southwestern Kenya were analyzed to deduce the concentration and distribution of natural occurring radioactive materials (NORM) in rock and soil samples. Evaluation of the environmental radioactivity and dose resulting from exposure to NORM. were analyzed in the laboratory using hyperpure Germanium (HpGe) detector to assess the concentrations of NORM. The average values of the radioactivity concentrations of ^{40}K, ^{226}Ra and ^{232}Th in the rock and soil samples were 915.6, 195.3 and 409.5 Bq kg^{-1}, respectively. The highest values of ^{40}K, ^{226}Ra and ^{232}Th concentrations (3017.8, 1567.5 and 1447.0 Bq kg^{-1}, respectively) were from samples collected at Homa Mountain and Chiewo hill which are both being encroached with human habitations. The gamma dose rate levels were determined using hand held survey meters in situ. The average outdoor absorbed dose rate in air at 1 m above the ground was found to vary from 108.4 to 1596.4 nGy h^{-1}. Energy Dispersive X-ray fluorescence when used was able to identify up to 18 elements among them K, Th and U. Using the concentration data obtained in this study, the range of the annual effective dose for a person living in Homa Mountain area was calculated to vary from 28.6 to 1681.2, with a mean of 470.4 μSv. The measurements show that the rock and soil samples from Homa Mountain have elevated levels of natural radioactivity qualifying the region as a high background radiation area. The implication is that local materials used for building and human settlements should be controlled by Radiation Protection Board. Access to Instrumental Neutron Activation Analysis would enhance the sensitivity and number of trace elements that can be deduced. The presence of rare earth elements provides possibilities for commercial exploitation that may result in economic benefit for the County and Country.

RADIOGENIC AND DOSIMETRIC CHARACTERISTICS OF ARTISANAL MINING OF A HIGH BACKGROUND RADIATION AREA 'CONFLICT MINERAL' COLUMBITE-TANTALITE

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The paper reports on the radiogenic and dosimetric study of extraction and processing of a 'conflict mineral' columbite-tantalite (coltan) in Rwanda using gamma-ray spectrometry and multivariate chemometrics. The study was motivated by the need for evidence-based development of a radiological regulatory framework for artisanal mining of conflict minerals in high background radiation areas (HBRA), which is widespread in Eastern Africa; and for developing a rapid method for forensic and quality assurance of coltan mining and trade utilizing coltan ore gamma-ray spectra as unique geochemical fingerprints. The mean activity concentrations of ^{238}U and ^{232}Th in mined coltan were found to be 513 Bq kg^{-1} and 57 Bq kg^{-1} respectively and that of ^{40}K was 267 Bq kg^{-1}. Measured absorbed dose rates varied 518.34 - 796.92 nGy h^{-1}, 522.4 - 820.7 nGy h^{-1} and 563.8 - 845.7 nGy h^{-1} in Muhanga, Ruli and Ngoma respectively the values being 11 times higher than world average, showing Rwanda's coltan mining belt is a HBRA. Measured dose rates were twice higher than computed rates based on measured activities, indicating the significance of gamma dose from radioactive dust and radon. Calculation of effective doses according to exposure pathways and working scenarios showed that total effective doses vary 0.0173 - 0.272 mSv y^{-1} in Muhanga, 0.013 - 0.525 mSv y^{-1} in Ruli and 0.022 - 0.255 mSv y^{-1} in Ngoma: inhalation of coltan bearing dust accounts for 98 % of the total exposure. Processing of coltan was found to enhance the concentration of ^{232}Th and ^{238}U by factors of 3 and 2 respectively, while it reduces that of ^{40}K by a factor of 15. Use of principal component analysis (PCA) of the radionuclides source-apportioned coltan to the respective mining areas and differentiated extracted from processed coltan accurately. Although the PCA also showed that artisanal mining practices hardly contribute to radiogenic contamination of the environment, results of this study raise important radiological and quality assurance concerns.

CAN TUMOR MARKERS SHED SOME LIGHT ON DARK CORNERS OF THE PUZZLING ISSUE OF CANCER INCIDENCE IN AREAS WITH ELEVATED LEVELS OF NATURAL BACKGROUND RADIATION?

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We have previously reported that in high background radiation areas (HBRAs) of Ramsar, the maximum credible annual radiation exposures are up to 260 mGy. If an annual radiation exposure of a few hundred mSv is detrimental to health, causes genetic abnormalities, or an increased risk of cancer, it should be evident in the residents. In spite of conflicting reports, some studies show that individuals residing in HBRAs of Ramsar have an increased frequency of detectable abnormalities in unstable chromosome aberrations. Similar higher than normal frequencies of chromosomal abnormalities have been found in other HBRAs. However, there is no reliable data indicating recognized increase in cancer rate in these areas. As large scale studies have shown that chromosomal aberration frequency in lymphocytes predicts the risk of cancer, this issue seems to be puzzling. To explain this discrepancy, some experts have argued that studies of HBRAs have not been conducted with sufficient sample size, replication or controls to estimate the shape of the dose response relationship. In this light, there are scientists who believe that the cancer rate is actually higher in HBRAs but it cannot be detected due to low population size. It has also been hypothesized that the residents of HBRAs may die in relatively young ages so there is possibly a different age distribution in the residents and the control group. Our findings do not support these hypotheses. We have previously reported radioadaptation in the residents of a HBRAs as well as a negative association between lung cancer mortality rate and radon concentration. A recent study again performed by our group confirmed the previous findings. Studies performed in other HBRAs also could not show a significant relationship between cumulative radiation dose and cancer rate. Recently, we studied the tumor markers in the inhabitants of HBRAs of Ramsar. The findings of this study only showed significant differences between the mean levels of CEA, Cyfra-21 and TAG 72 biomarkers of the residents of HBRAs and NBRAs. Statistically significant correlations were also observed between the external gamma radiation dose or indoor radon level and the concentration of CEA, Cyfra-21 and TAG 72 biomarkers. To overcome the limitations of sample size in epidemiological studies of HBRAs, we believe that studies such as those can be performed on tumor markers may shed some light on the dark corners of the challenging issue of cancer incidence in HBRAs.

POSTER PRESENTATIONS

RADIOLOGICAL INSPECTION IN AN OFFICE BUILT WITH CONTAMINATED ROD OF RADIOACTIVE MATERIAL, IN TLAQUEPAQUE, JALISCO, MEXICO.

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A company dedicated to the trading of scrap for the steel industry, located in the city of Tlaquepaque, Jalisco, Mexico, reported having purchased a batch of scrap-iron for construction to the "Federal Commission of Electricity". This batch included a steel rod for construction that had never been used, and this company used it to build an office. Later they purchased a radiation detector to monitor the scrap-iron they bought. When the detector supplier delivered it and showed how it worked, he began to register inside the office, levels much higher than the natural environmental radiation; the supplier thought that there was something wrong with the detector, he walked out of the office and noticed that the registers lowered to the normal levels. He went back into the office and monitored with special attention ""columns and cross"" where steel rods were embedded and he noted that readings soared even higher.

It should be noted that in 1983 took place in Ciudad Juarez, Chihuahua, ""The most important radiological accident occurred in Mexico in recent years"" (As classified the National Commission of Nuclear Safety and Safeguards, which is the regulatory body in Mexico in nuclear matter). It consisted of the involuntary smelting a source of Cobalt-60 (initially intended for medical use in teletherapy), which later was used in making rods for construction and metal table bases in the ""Chihuahua Steelers"" smelter. So the detector supplier suspected that the rods of the Tlaquepaque office come from this radiological accident.

Although in the Sciences Faculty of the Autonomous National University of Mexico, there is a portable multichannel analyzer system, which is able to identify the emitter radionuclides, for internal reasons, it could not be used.

SAFETY QUESTIONING OF THE OPERATION OF A PARTICLE ACCELERATOR MANAGEMENT AND RADIOACTIVE SOURCES IN THE SCIENCES FACULTY OF THE NATIONAL AUTONOMOUS UNIVERSITY OF MEXICO

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In the Department of Physics, Sciences Faculty of the National Autonomous University of Mexico there are three sites that handle radioactive sources and ionizing radiation generating equipment. These are “Modern Physics Laboratory”, ""Laboratory of Radiological Analysis of Environmental Samples"" and “Collisions Laboratory”. The first has two neutron sources, and other emission sources of gamma and beta radiation. Neutron sources are “Americium-241 Beryllium” and Californium-252, both have been operated with an expired license from the National Commission of Nuclear Safety and Safeguards (CNSNS), which is the regulatory body in Mexico in nuclear matter. This operating license (No. 183/85, file number 657) expired on 13 August 1987, that is, more than twenty five years ago, which led to the CNSNS prohibit its use. The Laboratory of Radiological Analysis of Environmental Samples was closed, later it was thought that a source of Barium-133 was illegally removed; later the CNSNS searched the laboratory and found that the radioactive source was always there, in possession of the Sciences Faculty Director, who declared that there had been an illegal extraction of the radiation source. The Collision Laboratory operated a Collision Experimental Particle Accelerator without an operating license; for this reason the CNSNS banned its operation.

The above issues may be considered bad practices on Radiological Protection, which must be eradicated to avoid radiation exposure of occupationally exposed personnel and members of the public.

This work was performed at the Sciences Faculty of the National Autonomous University of Mexico.

TECHNICAL QUESTIONING TO POWER UPRATES OF NUCLEAR REACTORS OF LAGUNA VERDE NUCLEAR POWER PLANT, MEXICO

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The two nuclear reactors at the Laguna Verde Nuclear Power Plant (LVNPP) of the Federal Commission of Electricity (FCE) underwent Power Uprates. These had the purpose of achieving a 20% increase over the original power. This work concluded in 2010, however, in 2014, the LVNPP has not received the new Operating License to operate with the new power from the National Commission of Nuclear Safety and Safeguards (NCNSS) (which is the regulatory body in Mexico in nuclear matter), because it did not satisfy the necessary safety requirements. Since 2005 some workers of the nuclear power plant showed their concern and expressed their technical arguments and opposition to the work; they considered it unreliable, risky and unaffordable. The recognition by the FCE and NCNSS of the existence of cracks in the jet pumps is one of the reasons why it has been restricted and has not been authorized to raise the reactor to its 100% power that had before the Power Uprates and this is one of the reasons why the new Operating License was not authorized. The Governing Body of the FCE has announced that look closely the performance and reliability of the operation of the nuclear power because the frequency of the unplanned interruptions had a sevenfold increase in the last three years.

Information about these problems was obtained from the FCE and NCNSS through the Federal Institute for Access to Information (FIAI). In this paper the above information is presented and discussed.

This work was performed at the Sciences Faculty of the National Autonomous University of Mexico.

DO COMMON WHEAT (TRITICUM AESTIVUM) SEEDS EXPOSED TO ELEVATED LEVELS OF NATURAL RADIATION RELEASE STIMULATING AGENTS IN THE CULTURE MEDIUM? SIMILARITIES WITH BYSTANDER EFFECT

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Over the past years our laboratory has focused on the biological effects of exposure to highly elevated levels of natural radiation in Ramsar. This study was aimed to investigate if common wheat (Triticum aestivum) seeds exposed to elevated levels of natural radiation release stimulating agents in the culture medium? Soaked seeds of Triticum aestivum were placed in petri dishes of 10 cm diameter filled with 5ml distilled water and exposed to gamma radiation (6.44±2.25 µSv/h) emitted from hot soil samples collected from high background radiation areas (HBRAs) of Ramsar. The control seeds received only normal levels of natural radiation (0.13±0.07 µSv/h) during the same period. The temperature and relative humidity in the germinator during the exposure phase were 25 ±1ºC and 60–65%, respectively. Irradiated seeds then were divided into 3 subgroups; R group in which the seeds were allowed to growth in the same culture medium; OSR in which irradiated seeds were cultivated in new culture medium; and NSR group in which new seeds were cultivated in the medium of the exposed seeds. Germination speed and plant weight (fresh and dry) and root length were measured in all plants. The germination speed in R, OSR, NSR and control groups were 21.5±2.41, 21.06±2.18, 17.49±2.1 and 14.61±3.0 Seedling/day, respectively ($P<0.05$). Plants' weight (Fresh) in R, OSR and NSR and control groups were 0.28±0.057, 0.3±0.051, 0.23±0.045 and 0.23 ±0.038 g, respectively ($P<0.05$). Plants' weight (dry) in R, OSR and NSR and control groups were 0.035±0.008, 0.037±0.006, 0.029±0.006 and 0.031±0.005 g, respectively ($P<0.05$). Plants´ root length in R, OSR, NSR and control groups were 7.4±2.96, 11.78±3.14, 7.5±3.44 and 5.8±3.5 cm, respectively ($P<0.05$). The findings of this study clearly show that seeds exposed to elevated levels of natural radiation release stimulating agents in the culture medium which increase the germination speed and root length. Further studies are needed to assess the possible mechanisms of this phenomenon which has similarities with the well-documented "bystander effect".

EXPOSURE TO ELEVATED LEVELS OF NATURAL RADIATION HELP BACTERIA BETTER COPE WITH THE LETHAL EFFECTS OF ANTIBIOTICS: IS THIS RADIOADAPTIVE RESPONSE DANGEROUS FOR HUMANS?

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The extraordinary levels of natural radioactivity in the high background radiation areas of Ramsar, Iran is reported to be due to high concentrations of 226Ra and its decay products, which have been brought to the surface by the waters of hot springs. Over the past years our laboratory has investigated different aspects of the challenging issue of the health effects of human exposure to highly elevated levels of natural radiation in Ramsar. This study was aimed to investigate the bacterial susceptibility to antibiotics in control and irradiated samples of Salmonella enterica subsp. Enteric, Staphilococcus areus and Klebsiella pneumoniae. Environmental monitoring in Talesh Mahalleh, a district in high background radiation areas (HBRAs) of Ramsar known for its high levels of natural radiation, was performed using a RDS -110 (RADOS. Inc., Finland) multi purpose survey meter. Before soil sampling, absorbed dose rates in air were measured at ground level and one meter above the ground level. Previously, in another study, soil samples were sent to the National Radiation Protection Department (NRPD) of the Iranian Nuclear Regulatory Authority for gamma spectroscopy. The concentrations of Ra-226, Th-232 and K-40 radionuclides in each soil sample were measured by using a high purity germanium (HPGe) gamma ray spectrometer (Canberra Industries). Culture plates were placed on a box filled with Ramsar hot soil. The exposure rate was measured by a Fluke 451 ion chamber survey meter. At the surface of the culture medium the exposure rate was 0.38 mR/h. After incubating the bacteria and allowing them to grow for 18 hours (37 ºC), diameter of the clear bacteria-free zone appeared around each antibiotic disk was measured. As, in Kirby-Bauer test the concentration of antibiotics which diffuses into the culture media decreases with increasing the distance from the antibiotic disk, a smaller area of bacteria-free culture medium surrounding an antibiotic disk can be interpreted as higher resistance against a specific antibiotic. Findings of our study showed that exposure of these microorganisms to radiation emitted from hot soils of the high background radiation areas of Ramsar increases their resistance to antibiotics. This was more prominent for Klebsiella pneumonia. Altogether, these findings confirm that high levels of background radiation can induce adaptive phenomena which help microorganisms better cope with lethal effects of antibiotics. In this paper we present evidence that shows this type of radioadaptive response which increases bacterial resistance against specific antibiotics can be dangerous for the residents of high background radiation areas.

A CONCEPTUAL MODEL FOR RAPID TRACE RADIOGENIC ASSESSMENT FOR QUALITY CHARACTERIZATION OF A COMPLEX ECOSYSTEM

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Modelling of coupled atmospheric, aquatic and terrestrial environment for system quality assessment utilizing trace radionuclides is a complex task considering the combination of analytical and temporal-spatial phenomena occurring at different scales and with various sources and sinks. Not only are the accurate concentrations of the analytes in the different environmental compartments important, but also precise knowledge about pollutant emission, immobilization and flux dynamics. This explains why forecasting of radiogenic pollutants in coupled complex ecosystems such as high background radiation areas with reasonable uncertainty is an open, challenging problem. Since conventional techniques for trace radiogenic quality characterization of the environment are currently based mostly on a combination of wet analyses (which are destructive and tedious), novel methods that are rapid, more comprehensive, reliable, accurate, simple and non-destructive, and able to measure and relate several parameters simultaneously are required. A systematized approach is thus required to design the analytical scheme and formulate the problem from the point of view of the study field in question, the instrumentation and spectroscopy, and multivariate (including geo-statistical) interpretation of the results in the context of the study objectives. In this paper we develop a conceptual model for a complex ecosystem defined in the context of trace radiogenic quality characterization and describe how to deploy machine learning in conjunction with gamma ray spectroscopy to realize a holistic application of trace radiogenic analyses to complex ecosystem quality characterization, starting with utility in design of experiments (sampling design), instrumentation and rapid quantitative analysis and multivariate data mining and exploratory interpretation to delineate sources, flux dynamics, and risk assessment and forecasting. We report our preliminary results in sampling design, instrumentation and analytical modelling.

ORAL PRESENTATIONS

AN EXPERIMENTAL METHOD TO QUANTITATIVELY ESTIMATE RATE CONSTANTS OF ELEMENTAL PROCESSES OF INDOOR RADIOACTIVE AEROSOL PARTICLE BEHAVIOR

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The purpose of this study is to develop an experimental method of quantitatively evaluating the elemental processes determining the indoor behavior of naturally occurring radioactive aerosols. Concentrations of radon and its decay products in air can be measured with commercially available equipment. Particle size distributions can be obtained with a low pressure cascade impactor combined with our imaging plate method for alpha particle counting. The idea used in the present study with these methods is to analyze the transitional temporal changes in the concentrations and the particle size distributions after turning on and off an air purifier which removes aerosol particles at a constant rate. It was pointed out by a theoretical consideration using a simplified working model describing generation, removal by deposition and removal by the air purifier that the rate constants of these processes can be deduced from the temporal changes in concentration as well as from equilibrium concentrations attained after the transitional period.

The method was successfully applied to rooms in a building of Nagoya University. The rate constant of deposition was consistently and hence reasonably evaluated from both of transition curves and equilibrium concentrations for both of radioactive and non-radioactive aerosols. It was found that the deposition rate constant was larger for radioactive aerosol particles smaller than 280 nm whereas there was no substantial difference in the rate constant between the particle size ranges of < 110 nm and 110 - 280 nm. It was also found that the deposition rate constant was systematically larger in the room with a smaller ratio of surface area (walls, floor, and ceiling) to volume of the room. The comparison of number concentrations of non-radioactive concentrations between indoor and outdoor environments showed that they were well correlated with a time delay in the temporal change in indoor concentration of about 30 min. The rate constant of outdoor-indoor exchange was estimated to be around 1 /h, which is comparable to the ventilation rate measured from the CO_2 concentration change.

NATURALLY OCCURRING RADIONUCLIDES IN DRINKING WATER IN SWEDEN - AN EXTENT OF THE PROBLEM AND THE CHALLENGE OF MAKING ACCURATE DOSE ESTIMATIONS

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In Sweden, high concentrations of naturally occurring radionuclides can be encountered in groundwater, extracted principally from bedrock. The radionuclides of interest include radon-222 and its long-lived progenies (Pb-210 and Po-210), uranium (U-238, U-234 and U-235) and radium (Ra-226 and Ra-228). Few surveys have been conducted to map and study the occurrence of radon and other radionuclides in drinking water. Dose estimation is principally based on radon concentration, but can be an underestimation when enhanced concentrations of uranium (exceeding 100 μg/l), Po-210 and Pb-210 are present in water samples. The aim of this study was to pool and review existing databases of measurement data in order to get a better overview of the extent of the problem in Sweden. Statistical analyses were performed to estimate mean values as well as for correlation purposes. Radiation doses that are likely to occur due to ingestion of water containing naturally occurring radionuclides were estimated and health implications were evaluated. Data on water quality and geology was obtained from the Geological Survey of Sweden. Dose calculation models from ICRP publications were reviewed. Preliminary results show that concentrations of radon exceeding 1000 Bq/l occur in a large number of wells. The highest concentration of radon registered was 66 000 Bq/l. The occurrence of radium-226 in drinking water was generally low. Uranium concentration exceeding WHO's revised guideline value of 30 μg/l was recorded in many wells. The highest concentration of uranium measured was 680 μg/l. Results of dose calculations will be presented in the conference paper.

COMPARATIVE STUDY OF THE NATURAL RADIOACTIVITY, CORRESPONDING RADIATION DOSE AND RADIOLOGICAL RISK IN THE URANIUM AND OIL REGIONS OF CAMEROON

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The objective of the present study is to compare natural radioactivity and corresponding radiation dose and radiological risk in the uranium regions of Poli, Lolodorf and the oil region of Bakassi in Cameroon. From some reported studies on natural radioactivity measurements and total dose assessment in Cameroon, radiological risk was determined using recommendations of the International Commission for Radiological Protection (ICRP). Activity concentrations, external radiation, ingestion and inhalation dose of each of the above regions were compared to the world average value given by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). Radiological risk of each region determined from the total radiation dose was also compared to the world average value. The specific case of indoor radon exposure was particularly considered. Radiological risk attributable to the indoor radon exposure was compared to the lung cancer rate in Cameroon given by the International Agency for Research on Cancer (IARC). Although the monitored areas mentioned above are not representative compared to the whole territory of Cameroon, it clearly appears that this cancer rate is largely underestimated.

Key words: natural radioactivity, external radiation, inhalation, ingestion, indoor radon, lead-210, polonium-210, radiation risk, lung cancer

STUDIES ON 226RA CONCENTRATION AND 222RN EXHALATION RATE FROM SOIL AND ROCK SAMPLES IN CHAMARAJANAGAR DISTRICT, INDIA

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Studies related to mankind exposed to radon have confirmed that radon in homes represents a serious health hazard. Radon enters into buildings mainly by crossing the soil-air or building material-air interface. Therefore, radon exhalation rate from soil is an important aspect for estimating local environmental radon level. The soil and rock samples were collected from different locations of the study area, and 'Sealed Can Technique' was used for the measurement of radon exhalation rate from soil and rock samples, by following SSNTD method, using LR-115 type- II plastic track detectors, and concentration of radium was calculated. Chamaraja Nagar district is located in the southern tip of Karnataka state in India. The district has vast reserves of black granite. In soil samples mass exhalation rate of radon varies from 10.0 to 31.4 mBqkg-1h-1 and surface exhalation rate of radon varies from 142.0 to 918.4 mBqkg-1h-1. In rock samples mass exhalation rate of radon in varies from 8.0 to 119.7 mBqkg-1h-1 and surface exhalation rate of radon varies from 93.9 to 1787.3mBqm^{-2}h^{-1} respectively. Gamma ray spectrometry (HPGe) method was used to estimate the activity concentration of ^{226}Ra in soil and rock samples. The activity concentration of radium ^{226}Ra, in soil samples varies from 4.85-14.15 Bqkg^{-1}, and that in rock samples ranges from 3.37-187.04Bqkg^{-1}.

INVESTIGATION OF LEAD CONCENTRATION IN COW TEETH WITHIN OTA AN URBAN TOWN OF ABEOKUTA

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In this study, 3 sites of cattle grazing and slaughtering for marketing were identified in Ota, an industrial city in Ogun state Nigeria. The cattle slaughtered from these sites (A, B and C) were analyzed for the presence of Lead using an Atomic Absorption Spectrophotometer (AAS) model S4 series, Model (GBC 906) (USA). The highest mean level of Lead concentrations present in the teeth of the cow slaughtered were recorded for each site as Site A = 0.0730 ± 0.00954μg/ml, Site B = 0.2585 ± 0.00853 μg/ml; and for Site C = 0.1111 ± 0.02315 μg/ml. From the results obtained, we can conclude that Lead pollution in the environment is of ecological concern. Of these 3 sites, between 15% and 35% of all cattle had lead concentrations consistent with acute lead poisoning (greater than 0.29 μg/ml), and between 33% and 48% of these cows were in the high-normal range (0.1– 0.34 μg/ml).

MEASUREMENTS OF U AND RA ACTIVITIES IN DRINKING WATER SAMPLES AND OF RN IN DWELLINGS IN MOROCCO AND EVALUATION OF THEIR CONSEQUENCES

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The natural radioactivity comes mainly from the primordial radio-nuclides in soils (^{40}K and the 4n and 4n+2 series). Further, some cosmogenic radionuclides and/or radionuclides originated from a pollution can be found in natural waters used for drinking. The natural polluting radio-elements can rise from industrial wastes, geological erosion of U-bearing rocks or excessive utilization of agricultural fertilizers. Concentrations of natural radio-elements in water depend on the physico-chemical conditions and on the geological, geographical and socio-economical environment.

Radon gas (^{222}Rn) is commonly found in the environment and is known to be one of the principal sources of natural radiation exposure among human beings. Most of this exposure occurs inside homes, where many hours are spent each day and where the volumic activity of radon is usually higher than outdoors.

In this work, we have measured: (i) the activities of principal U and Ra isotopes such ^{234}U, ^{238}U, ^{226}Ra and ^{228}Ra in some drinking water samples, (ii) the volumic activities of Rn in some indoor dwillings and workplaces in Morocco. Then we have calculate from these results the equivalent doses and we have comparative them to Annual Limits of Incorporation by ingestion recommended by the International Commission of Radioprotection.

Activities of uranium and radium isotopes (^{234}U, ^{238}U, ^{226}Ra, ^{228}Ra) for some drinking water samples collected from wells, springs and tap water samples were measured. The obtained results show that the ^{238}U activity, is relatively higher in wells than in springs and unlike ^{238}U, ^{226}Ra activity is more higher in hot springs. A comparison of ^{234}U and ^{238}U activities show that there is an important disequilibrium between the two radio-isotopes in hot springs. Uranium and radium activities are similar to those published for other non-polluting regions of the world. Calculation of equivalent doses show that these activities are inferior to the maximum contaminant levels recommended by the International Commission of Radioprotection and they don't present any risk for public health in Morocco.

For radon,. The obtained results show that the effective dose calculated for indoor dwellings are comparable to those obtained in other regions in the word. The risks related to the volumic activities of indoor radon could be avoided by simple precautions such the continuous ventilation. Seasonal variation of Radon activities and Relationships between variation of these activities and some parameters such height, depth and type of construction were also established in this work.

NATURAL BACKGROUND RADIATION MEASUREMENTS ON THE FIRST POLISH NUCLEAR POWER PLANT SITE

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Environmental studies conducted within the framework of the first Polish nuclear power plant (NPP) build project are both multilayered and comprehensive. They encompass, among others, background radiation monitoring, which in its turn includes measurements of both naturally occurring and human-activity induced radioisotope concentration levels in the air, water and soil. They also comprise measurements of gamma radiation dose rates. Gathering such data is required before the construction of an NPP on a given site as such information will allow for efficient radiation monitoring of the facility and its surroundings in the future. The presentation that follows outlines the methodology for the measurements conducted, lists the radioisotopes under analysis, names the types of dosimeters used in the studies as well as provides detailed maps and a measurement points network in both potential NPP sites in Poland.

MEASUREMENT OF URANIUM, THORIUM AND URANIUM ACTIVITY RATIO IN ENVIRONMENTAL SAMPLES FROM A TROPICAL COUNTRY, THAILAND

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Concentration of uranium and thorium in selected plants and soils from four provinces in southern Thailand have been studied. These selected provinces are proposed as potential sites to set up nuclear power plants (NPPs) as well as coal-fired thermal power plants. Concentration U and Th was determined using the inductively coupled plasma mass spectrometry (ICP-MS). The highest concentration of U and Th in selected plants was 0.67 ug/g (8.33 Bq/kg) and 2.46 ug/g (10.02 Bq/kg), respectively. The concentrations in vegetable were higher than those in fruit and rice. U and Th concentrations in plants were lower than their relevant soil. The concentration in the relevant soil ranged from 0.35 – 7.64 ug/g (4.36 – 95 Bq/kg) for U and 1.86 – 33.97 ug/g (7.56 – 138.38 Bq/kg) for Th. Activity ratio of uranium (234U/238U) in soil samples were determined using thermal ionization mass spectrometry (TIMS).

ENVIRONMENTAL RADIOACTIVITY IN GOLD MINING IN BURKINA FASO

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The mining industry is developing in Burkina Faso. The country has eight mines in operation, more than 200 artisanal mining and legacy sites from past mining. Naturally-occurring radionuclides like those of uranium (^{238}U), and thorium (^{232}Th) decay chains, and potassium (^{40}K) ubiquitous in earth can sometimes be found in higher concentrations in gold ores. These co-occurring radionuclides can be released during mining operations and ore processing. A lot of people currently work inside these mines and in related activities although no information on natural radioactivity levels and assessment of the risk of exposure to ionizing radiation have been made available. Mine workers are also exposed to re suspended dust particles which size can vary from 0.3 µm to 10 µm according to some studies. Following their size, these particulates can be inhalable and reach bronchia and enter the systemic circulation. Neither an investigation has been previously made on natural exposure rate in Burkina Faso. In order to assess the natural exposure, the Autorité Nationale de Radioprotection et de Sûreté Nucléaire (ARSN) in cooperation with the Institute Superior of Technology of Portugal, proceeded to an evaluation of environmental radioactivity by direct measurements of radiation dose rate on mining sites and collection of soil and mine waste samples for analysis in the laboratory. Twelve points have been concerned by dose rate measurements. These measurements were made using portable dose rate meters, like the Radeye and the Radiagem, and samples collected were analyzed in the laboratory by radiochemistry and alpha spectrometry. The dose rates recorded on gold mine sites were between 0.02 to 0.08 µSv/h, which suggests that radiation exposure could be to average radiation background only. More detailed radionuclide analyses are in progress.

THE OPTIMIZATION OF ELECTROKINETIC REMEDIATION FOR HEAVY METAL CONTAMINATED OF HOLYROOD-LUNAS (ACRISOL SPECIES) SOIL IN SRI GADING INDUSTRY AREA, BATU PAHAT, JOHOR, MALAYSIA

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The optimization of electrokinetic remediation of an alluvial soil, namely Holyrood-Lunas from Sri Gading Industrial Area, Batu Pahat, Johor, Malaysia has been conducted in this research. This particular soil has been chosen since it's background radioactivity level is quite high compared to the other alluvial soils. It's surveymeter reading was recorded in range of 50 to 60 microRoentgen per hour and approximately three times higher compared to the other alluvial soils. The anomaly of this reading could be contributed by the contamination of heavy metal from this industrial area. As the background radiation is correlated to the amount of parent nuclides, ^{238}U and ^{232}Th, hence a remediation technique such as electrokinetic remediation is very useful in order to extract and reduce this particular element concentration in soils. The electrokinetics experiments were performed in bench laboratory-scale. The optimization parameters to be studied in this study are the electrokinetic treatment time (t/hour), the voltage across the anode-cathode (V/volt), the spacing between the two electrodes (d/cm), the dimension and size of the electrodes and the electrodes configurations in 1-dimensional and 2-dimensional orders. The best optimization condition for each parameter is determined based on the different in soil elemental composition between pre and post electrokinetic remediation. Here, X-ray fluorescence (XRF) and Hyper Pure Germanium (HPGe) spectrometer were used for elemental analysis. The results of the pre and post electrokinetic will be discussed in details in this paper.

Keywords: electrokinetic remediation; optimization; natural radioactivity; alluvial soils; XRF; HPGe

STUDY OF POLONIUM CONTENT IN CIGARETTE SMOKE

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Nowadays, several juridical steps have been taken to confine smoking in several countries of the world. Despite this, smoking still takes the lives of lots of people year after year.

Processed tobacco, and therefore cigarette contains several dangerous and harmful substances such as tar. However, besides these contaminations polonium is also found in considerable amounts. This is due to the fact that the tobacco plant can adsorb polonium in a great amount during its growing period, which does not pass during the processing.

In this study the polonium content of cigarette smoke was examined based on different aspects. A smoking machine prepared by ourselves was used for the measurements, which has been working based on parameters set out in the relevant standard. The machine was designed to provide 35 mL puffs lasting for 2 seconds. Then cigarette smoke was lead through gas scrubbers, and polonium sources were made of the solutions using spontaneous deposition. The sources were measured using a semi-detector alpha-spectrometer.

During the study the absorber solutions best suitable for catching the polonium content of the smoke were examined. The concentration of polonium in cigarette was measured and was compared to the concentration in smoke. It was used for determining the ratio of polonium in the cigarette escaping with smoke.

The measurements also covered same cigarette types with different nicotine content and the relationships between polonium concentration and nicotine content were examined. Finally, cigarettes made of tobacco grown in different locations were examined. No considerable differences between growing locations were found.

MEASUREMENT OF RADIOACTIVITY AND HEAVY METAL LEVELS IN EDIBLE VEGETABLES AND THEIR IMPACT ON KUALA SELANGOR COMMUNITIES OF PENINSULAR MALAYSIA.

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Vegetables are an essential daily diet item for the people of Malaysia. This work addressed the radiation and heavy metal exposure scenarios through the consumption of vegetables. Kuala Selangor is located in Sungai Selangor estuary in the west coast of Peninsular Malaysia which is susceptible to pollution load as a lot of industrial and human activities are located in this area. Radioactivity and heavy metals level in human diet is of particular concern for the assessment of possible radiological and chemical hazards to human health. However, very few surveys of radioactivity and heavy metal in foodstuffs have been conducted in the mentioned area. A comprehensive study was carried out to determine the radioactivity levels (^{226}Ra, ^{228}Ra and ^{40}K) and heavy metal concentrations (Cr, As, Mn, Mg, Al, Sr, Mo, Rb, Sn, Sb, Ba, Hg, Fe, Ni, Zn, Cu, Bi and Pb) in ten varieties of vegetable collected from different farmlands in Kuala Selangor region, Malaysia. The daily intake and committed dose due to consumption of vegetables by the public was estimated. The committed dose for ^{226}Ra, ^{228}Ra and ^{40}K due to consumption of vegetables were found 16.4, 27.5 and 57.6 μSv y^{-1}, respectively with a total of 101.5 μSv y^{-1}. This dose imposes no significant threat to human health. The estimated cancer risk shows that probability of increase of cancer risk from daily intake of vegetables are only a minor fraction of ICRP values. The concentrations of heavy metal were below the daily intake recommended by the international organizations.

STUDY OF RADIOACTIVITY DURING THE TREATMENT OF WASTEWATERS BY A PHOSPHATE BED

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In Morocco, the phosphate industry uses a very large amount of water for washing and flotation extraction products. This amount is increasing over the years with the increase of phosphate's production by the OCP Group.

Thus, to meet this additional demand for water, a new process for treatment of wastewater has been developed this concerns the infiltration - percolation through a bed of phosphate. This innovative process has achieved the objective quality of treated water for the main parameters of pollution.

However, a study of the distribution of radioactivity in the various components of the filter bed consisting essentially of phosphate is interesting to verify whether or not radioactive elements, in particular uranium and thorium. Theoretically, the risk of the passage of the radioactivity in the water treated by the phosphate is possible, where the importance of checking if this radioactivity exceeds the international standards.

The determination of the radioactivity was carried out by two different methods: the high resolution gamma spectrometry and solid state nuclear track detectors (SSNTDs)

ENVIRONMENTAL RADIOACTIVITY ANALYSIS IN MERSIN, TURKEY FOLLOWING THE FUKUSHIMA DAI-ICHI NUCLEAR ACCIDENT

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Following Fukushima Dai-ichi Nuclear Power Plant accident huge amounts of radionuclides were released in atmosphere and ocean. All over the world governments have carried out environmental radioactivity monitoring; external dose rate, radioactivity measurements in environmental samples and others. Several soil, beach sand and water samples were collected from the Mersin city in September, 2012, and radioactivity concentrations of ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs were determined by gamma spectrometry using a high-purity Germanium detector. The absorbed gamma dose rate (D), the radium equivalent activity (Raeq), the external hazard index (Hex) and the annual effective dose (AED) of soil samples were calculated and compared with the maximal admissible values and the measurement results held in 2011 before the Fukushima Dai-ichi Nuclear Power Plant accident. Findings are in good agreement with the published results of neighboring areas. Also there is not any sign for ^{134}Cs and any significant increase in the radiation levels after Fukushima Dai-ichi Nuclear Power Plant accident.

The average value of gamma dose rate obtained in this study is around the world average. Also calculated average values for Raeq, Hex and AED show that the radiation hazard is insignificant.

USE OF NATURAL AND ARTIFICIAL RADIONUCLIDES FOR SEDIMENTATION RATES DETERMINATION IN CORES FROM SOUTHEASTERN PART OF BRAZIL

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Estuarine systems have an enormous environmental relevance due to its hydrodynamic and geomorphological characteristics and mainly its proximity with coastal areas which are impacted by different anthropic activities. In the Southeastern part of Brazil, in São Paulo state, there are two important areas with distinct environmental concerns. In Santos estuary it is located the largest harbor in Latin America, an environmentally degraded area due to both domestic and industrial pollution, responsible for microbiological and chemical contamination; physical alterations of habitats due to erosion processes, silting up, dredging activities, channels and mangrove embankments; and interventions in the drainage system. The second area, Cananeia-Iguape region, consists of an estuarine and lagoonal complex system, and has been suffering dramatic environmental changes along the last 150 years initiated by an artificial channel (the Valo Grande channel) which connected the Ribeira de Iguape River to the estuarine system. Mining activities that took place in the upstream regions changed this area and it has acted as a final destination of contaminated sediments. In both systems were collected cores using a vibrocorer equipment. The cores were opened and sampled each 2 cm, the sediments were freeze-drying and the levels of 210Pb and ^{137}Cs were determined by gamma spectrometry using a low background of Ge hiperpure detector. The ^{210}Pb and ^{137}Cs radionuclides were measured at 46 keV and 661 kev, respectively. From these radionuclides activities it was possible to establish sedimentation rates for the studied areas by different models of ^{210}Pb unsupported and ^{137}Cs fallout; the results varied from 0.8 to 1.3 cm y-1 for Santos estuary and from 0.6 to 1.1 cm y^{-1} for Cananeia-Iguape estuary. The results obtained allowed to evaluate the depositional processes along the cores and it was possible to understand the sedimentary dynamics and environmental changes due to anthropic activities.

SUGGESTIONS FOR THE IMPROVEMENT OF ENVIRONMENTAL RADIATION MONITORING IN KENYA

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Environmental radiation monitoring in Kenya was started in 2000 following the 1979 Three Mile Island and the 1986 Chernobyl nuclear power plants accidents. The main purpose was to measure the radioactivity of foodstuffs imported from oversees especial Europe and to carry out environmental radiation monitoring of soil, rock, water and air samples to check for contamination. Through environmental radiation monitoring, the Food and Environmental Monitoring Section (FEM) of the Kenya Radiation Protection Board (RPB) works to protect the public and environment from hazards associated with ionizing radiation. The purpose of this paper was therefore, to highlight suggestions for the improvement of environmental radiation monitoring in Kenya with respect to protecting the public and the environment against undue radiation risk by ensuring that potential exposures are kept As Low As Reasonably Achievable (ALARA). Through the review and comparison of environmental radiation monitoring documents, publications and reports of various advanced countries the author identified weak areas that needed improvement and proposed ways of strengthening environmental radiation monitoring in Kenya. The author is optimistic that the suggestions for improvement presented herein will serve as a guideline for the strengthening of environmental radiation monitoring program in Kenya. Moreover, these suggestions will help in the amendment of the already existing Radiation Protection Act.

CESIUM-137 AS A TRACER OF CURRENT SOIL TURBATION

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Soils with disturbed profile as a result of cryogenic heaving and windfalls are quite common in boreal and tundra landscapes worldwide. Such soils frequently contain burial organic material formed at the surface. Turbation is originated by mixing of materials from various horizons of the soil down to the bedrock. Due to global radioactive fallout, ^{137}Cs deposition occurs in various landscapes. Cesium-137 is a slightly mobile isotope, that`s why accumulation of cesium-137 takes place in surface soil. Thus, location of anthropogenic radionuclide in buried organic horizons indicates its conservation in the soil profile on the one hand, and can be used to diagnose young soil turbation on the other hand.

The goal this paper is to analyze the possibility of using cesium-137 as a tracer for identification of current soil turbation.

Field research was carried out in 2012 in boreal landscapes in the center of Western Siberia (Russia). We found 3 soil pits with turbation and 29 soil pits with undisturbed profile on the two key study areas. Peat interlayers were moved at the depth in two soil profiles. 180 samples (including 3 samples of turbation layers) were taken from 32 soil pits to determine the specific activity of cesium-137 using gamma spectroscopy.

In the soils with undisturbed genetic horizons vertical distribution of cesium-137 is characterized by surface accumulation. Moss-grass-underwood layers contain 22±20% of ^{137}Cs total storage in the landscapes of oligotrophic bogs with cryohistosols and pine forests on cryopodzols. 90% of 137Cs soil storage accumulates in the soil up to 10 cm. However, there were exceptions. We found that not only the upper layer of soil (0-20 cm) contained ^{137}Cs. In three samples (of the two soil profiles), moved from the surface with large amounts of organic matter, we detected significant activity of cesium at a depth of 12-20 cm and 20-40 cm.

Thus, we have proved the possibility of movement of the cesium-137 in the deep soil layers due to mechanical movement caused by cryoturbation and windfalls. That is, there is a natural mechanism of deactivation of the surface soil horizons in the soils of the North.

Further research will be devoted to analyzing the frequency of occurrence of current soil turbation and calculation of cesium-137 reserves, which may be buried in them.

TWO TYPES ^{137}CS VERTICAL DISTRIBUTION IN THE BOTTOM SEDIMENTS THE KARA SEA MARGINAL FILTER

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Two anomalous ^{137}Cs zones are identified in the Kara Sea marginal filter. They were formed under the influence of geochemical barriers on the movement of Ob and Yenisei river waters radioactive contamination. Ob zone is characterized by 40-45 Bq/kg values in the surface sediments and more than 100 Bq/kg in some underlying horizons. Set pollution levels are higher in the Yenisei area: plots with the activity of more than 70 Bq/kg are located in the upper layer of sediments and 260 Bq/kg in the lower horizons. To study the vertical distribution of ^{137}Cs in the sediments of both areas - 47 columns of precipitation were used with a total of 1342 samples. Distribution of ^{137}Cs to the layers graphs were constructed for each of the columns of the sediments. Sixth degree Polynomial trend-line and mean square deviation (R2) were added to each graph. Averaged graphs were constructed based on the average values of specific activity on the horizons of precipitation of the vertical distribution of radiocesium in the sediments of both bands and lines of polynomial trend sixth degree were added. The computed R2 was 0.073 for Ob zone and 0.985 for the Yenisei area. Combined graphs show the differences of vertical distribution of ^{137}Cs. Thus, the spatial position of the Ob and Yenisei zones comparing to their facies zonation is indicative of their direct relationship to the facies conditions estuaries and inner shelf. This shows the similarity of the depositional environment in both areas. On the other hand sharp differences in the vertical distribution of ^{137}Cs indicate that his admission to the Ob area was of "ragged" nature and lower levels of activity, and radiocesium collected in the Yenisei region, did a more "natural", reaching maximum values in the horizons, formed in the 60 years of the twentieth century.

BEHAVIOUR OF ISOTOPES OF U AND TH IN MOROCCAN SEDIMENTARY ROCKS: METROLOGY AND GEOCHEMISTRY

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Stable and radioactive elements are very useful in the soil and sediment geochemistry studies. In this context, the present work was focused on the behaviour of stable elements and radisotopes of U and Th in order to deduce the geochemistry of sedimentary deposits composed t of phosphate, limestone, marl, marly clay and , oil shale. Samples from different depths and term were analysed. The isotopes of uranium and thorium were measured by radiochemical alpha spectrometry. Elemental and morphological characterizations were performed by ICP-AES and SEM-EDX respectively. In order to assess the behaviour of U and Th radisotopes, the $^{234}U/^{238}U$, $^{230}Th/^{238}U$ isotopic ratios were exploited and the dynamics of the studied system was approached. The distribution of U in the different phases of sedimentary rocks was carried out by sequential extraction and the isotopic ratios were determined.

POSTER PRESENTATIONS

THE NATURAL AND ARTIFICIAL RADIOELEMENTS IN POLLUTED AND INDUSTRIAL AREA IN NORTH WEST OF ALGERIA

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The level of naturally and artificially radioactivity in samples were collected from polluted, industrial regions and building materials of Oran have been investigated. The samples were analyzed by direct gamma spectrometry measurement made using a NaI(Tl) scintillate detector to identificate radionuclides that can be possibly present in soil and water like: ^{238}U, ^{232}Th (and their daughter), ^{40}K, ^{246}Cm, ^{137}Cs and ^{242}Pu. Activity concentrations of ^{238}U, ^{232}Th, ^{40}K, ^{246}Cm, ^{137}Cs, ^{242}Pu were found.

MANAGEMENT OF GROUNDWATER NATURAL RESOURCES IN DISASTER AREA TO ENSURE ENVIRONMENTAL SUSTAINABILITY

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Weak government oversight for the construction of multi-storey buildings sector in areas such as in Jakarta and the provision of infrastructure is inadequate. It has got an impact to open green space increasingly narrows. Groundwater in Jakarta which has been mixed with sea water cause brackish water and it seems to be causing a crust in pan if used to cook. 87% decrease in soil in Jakarta due to a multilevel buildings. Causing a decrease in groundwater up to 5 metres annually in Jakarta. Excessive exploitation in Jakarta will lead to disastrous flooding. In addition, the industry also gained ground water such as in Malang, there are 1.800 of 1.980 the company has been using groundwater but do not have permission to use. So, there are not policy for the use of water in industry and the disposal of the industry that are not processed or without going through any process resulting in the deterioration of groundwater which is getting worse. Should use of groundwater is a last resort when the supply of clean water is hard to obtain. The lack of provision of adequate infrastructure to cope with the industry's reliance on groundwater. Rainfall that cannot be absorbed by the ground making conditions getting worse. Excessive use of groundwater will lead to soil degradation and rising sea water indirectly but if left would be dangerous. There are a few key points for groundwater issues, are: seriousness of efforts to manage water in a sustainable way and the conservation ,affix area or infiltration water area that is able to grow naturally should be managed properly, because it is already polluted, need to manage the overflow area, the zone where the water was issued or worn. Decline of water quality caused by pollution of domestic waste and industrial activities , and the physical aspects is conservation of water, while the social aspect is the awareness of water management.

INVESTIGATION OF NATURAL RADIOACTIVITY IN DRINKING WATER IN YAOUNDE AREA, CAMEROON AND COMPARISON WITH RESULTS FOUND IN MOROCCO

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The average concentrations of natural radionuclides in reservoir, tap and spring water in Yaoundé area, capital city of Cameroon, populated today about 3.5 million inhabitants were estimated from measurements of mean specific activity using gamma spectrometry. Water samples from reservoirs and taps were collected during the dry and the rainy seasons, respectively in December 2002 and July 2003 and spring samples water were collected in August 2010. The radionuclides observed with regularity belonged to the series decay naturally occurring radionuclides headed by ^{238}U and ^{232}Th as well as the non-series nuclide ^{40}K; but we were interested to ^{226}Ra and ^{228}Ra who can lead by ingestion in significant doses, cancerous lesions located on the long bones (thighbone, tibia, fibula, and humerus) but also on the flat bones (scapula and the bones of the skull) (CIPR, on 1996).

The average specific activity values obtained for ^{226}Ra (fission product of ^{238}U) and ^{228}Ra (daughter of ^{232}Th), respectively were from reservoir water 8.73 ± 3.50 $Bq.L^{-1}$ and 0.57 ± 0.28 $Bq.L^{-1}$ during the dry season; 8.54 ± 3.68 $Bq.L^{-1}$ and 0.61 ± 0.26 $Bq.L^{-1}$ during the rainy season. For tap water we have respectively 11.40 ± 3.71 $Bq.L^{-1}$ and 1.02 ± 0.31 $Bq.L^{-1}$ during the dry season; 9.14 ± 3.50 $Bq.L^{-1}$ and 0.68 ± 0.26 $Bq.L^{-1}$ during the rainy season. For spring water, the average concentration of ^{226}Ra and ^{228}Ra (rainy season) are respectively 3.20 ± 0.35 $Bq.L^{-1}$ and < 0.0002 $Bq.L^{-1}$. These results will be compared to those found in the same sources of natural water in Morocco.

The average annual intake for these populations due to ^{226}Ra and ^{228}Ra is 3354 Bq/y for reservoir water, 3821 Bq/y for tap water and 1161Bq/y for spring water. The annual effective dose received by Yaoundé adult population as a result of ingestion of this drinking water (1L per day) is respectively 0.925 mSv for the reservoir water, 1.052 mSv for the tap water and 0,255 mSv for spring water. According to ICRP recommendations (1991), the limit for public exposure should be expressed as an effective dose of 1 $mSv.y^{-1}$. Knowing that the doses obtained for our samples water are in this limit, the populations which use these waters are predisposed to no risk of radioactive pollution. However if we consider stochastic effects of radium isotopes, there is a need for regular monitoring the water quality in this country as a whole since high radiation doses as well as low radiation doses of ^{228}Ra and ^{226}Ra could induce long bone cancerous lesions. People can then filter this water before consumption because by filtrating, the radioactive substances that couldn't be dissolved have been eliminated.

EFFECT OF GEOMETRIC STRUCTURE AROUND DETECTOR AND INFILTRATION OF RADIONUCLIDES ON RADIOACTIVITY CONCENTRATION ESTIMATION FROM NAI(TL) PULSE HEIGHT DISTRIBUTION

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Pulse height distributions measured by NaI(Tl) scintillation detectors are continuously monitored around nuclear power plants to identify release of radionuclides from the plants. It is useful for evaluation of radiological consequences to estimate air/surface radioactivity concentrations from pulse height distributions measured at a monitoring station (MS). However, it is essential to consider shielding effects caused by buildings and ground surface undulations (geometric structure) around each MS and source distribution including infiltration of radionuclides. In this study, a method to estimate surface radioactivity concentrations of radon decay products from pulse height distributions is discussed by considering geometric structures around MSs and infiltration of radionuclides.

The surface concentrations of Pb-214 and Bi-214 were estimated by comparing the full-energy peak count rates of pulse height distribution between observation and calculation. Calculations of pulse height distribution with the EGS5 code were conducted for the following three cases: Case 1 assumed that radionuclides were uniformly distributed on the flat ground surface; Case 2 assumed that radionuclides had spatial distribution on roofs and ground surfaces including the shielding effects by obstacles; Case 3 was same as Case 2 but with infiltration into soil considered.

The estimation method was applied to the observations obtained with 3″ϕ×3″ NaI(Tl) scintillation detector at near-by five MSs around the Hamaoka nuclear power plant in Shizuoka, Japan. Observation data were selected to ensure that Pb-214 and Bi-214 deposition amounts were almost the same among the MSs. The concentrations in Case 2 were estimated to be larger than that in Case 1. This difference between the cases was enhanced at the MSs with more high buildings, implying that the assumption of the uniform source distribution on a flat ground surface is oversimplified. The fact that, in Case 2, the difference in estimated concentration are smaller difference among the MSs indicates reasonableness of considering the geometry of obstacle and source distributions although the calculated pulse height distribution in a low-energy part was smaller than the observed one. The consideration of infiltration (Case 3) resulted in better agreement between the calculated pulse height distribution and the observed one than in other cases. However, the concentrations were estimated to be systematically smaller by 20% for MSs with larger gamma ray contributions from sources on building roofs and paved areas, probably caused by larger surface run-off of radionuclides from those areas.

A DISCUSSION ON THE NEED OF GUIDELINES TO CONTROL RADIONUCLIDES IN COMMERCIAL FOOD DURING NORMAL CONDITIONS

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In Canada and for many other countries and international organizations, guidelines to control radionuclides in commercial food were established for emergency situations. Therefore, most of these guidance documents provide guideline levels only for those radionuclides representative of a nuclear or radiological emergency, such as 137Cs, 131I, and 239/240Pu. In this paper, a discussion is given on the need of food quality guidelines to control radionuclides in commercial food in non-emergency or normal situations. Under normal conditions, naturally occurring radionuclides in food become the main concern for radiological protection and food quality control.

Natural radionuclide levels in food are not normally a concern for the general public or for many governmental organizations responsible for food safety and public health. Even in emergency cases where the effects from natural contaminants often significantly outweigh that from artificial or man-made contaminants, people still tend to focus on man-made, and overlook more significant contaminants simply because they are naturally occurring. This lack of a radiological protection culture in non-emergency situations makes the risk communication much hard in emergency situations. Guidelines for drinking water quality developed in many countries as well as the World Health Organization are good examples of radiological guidelines for non-emergency situations. Drinking water guidelines provide maximum acceptable concentrations (MAC) for more than eighty different radionuclides potentially found in water, either from natural origin or resulting from human practices or nuclear accidents. The experience with drinking water guidelines could be applied to food guidelines. Drinking water and food are equally important to public health in normal situations as well as in emergency cases. Food safety should meet the same standards as drinking water quality. From the perspective of radiological protection, quality guidelines or safety standards to control radionuclides in foodstuffs are needed in non-emergency situations.

While Codex standards do not apply to non-emergency situations, China has recently revised its national food safety standard GB14882 –Restriction Concentrations of Radionuclides in Foods in which it is clearly stated that the standard shall apply to all kinds of food under normal conditions. A standard for normal conditions includes, therefore, restrictions of naturally occurring radionuclides in food in addition to restrictions on artificial isotopes. With increasing international trade, different food standards could cause administrative burdens and an undesired economic impact. There is a need for harmonized international food safety standards under normal conditions which impact our everyday life. With this harmonized international food safety standard, consumers can trust the safety and quality of the food products they buy, and importers can trust that the food they ordered will meet their specifications regardless where they are produced. More issues will be discussed further.

CONCENTRATION OF ^{129}I IN AQUATIC BIOTA COLLECTED FROM A LAKE ADJACENT TO A SPENT NUCLEAR FUEL REPROCESSING PLANT, ROKKASHO, JAPAN

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The spent nuclear fuel reprocessing plant in Rokkasho, Aomori Prefecture, Japan, has been undergoing final testing since March 2006. Actual spent nuclear fuels were cut and chemically processed from April 2006 to October 2008. During in the operation, the plant discharged radionuclides, including ^{129}I, into the atmosphere and the coastal waters. In order to determine the behavior of ^{129}I in Lake Obuchi, a brackish lake adjacent to the reprocessing plant, the concentrations of ^{129}I in various aquatic biota samples (fish, sea grass, bivalves, and shrimp) in the lake were measured by an accelerator mass spectrometry (AMS). We fund that owing to discharge of ^{129}I from the plant, the ^{129}I concentration in the aquatic biota rose from the background concentration starting in 2006 and was highest during 2007–2008. The ^{129}I concentration has been rapidly decreasing since 2009, that is, after the fuel cutting and chemical processing were finished. The annual committed effective dose due to ingestion of foods with the maximum ^{129}I concentration in the biota samples in Lake Obuchi was estimated to be 2.8 nSv y^{-1}.

This study was performed under a contract with the government of Aomori Prefecture, Japan.

TRITIUM CONCENTRATION IN SHALLOW GROUNDWATER COLLECTED IN ROKKASHO, JAPAN, FROM 2009 TO 2012

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At the large-scale commercial spent nuclear fuel reprocessing plant in Rokkasho, Aomori Prefecture, Japan, final test operation with actual fuel began in March 2006, and regular operation is scheduled to start in October 2014. Tritium is one of artificial radionuclides released from the reprocessing plant, and excess ^{3}H is expected to be found in environmental waters around the plant. To study the influence of ^{3}H released from the plant, ^{3}H concentrations in shallow groundwater samples collected from eight drilled observation wells in the catchment area of the middle and downstream reaches and the estuary of the Futamata River were measured from 2009 to 2012. The Futamata River is one of the main streams flowing into Lake Obuchi, a brackish lake adjacent to the plant. A pair of 25-m-depth and 5-m-depth wells was drilled at each of four observation points. In addition, ^{3}H concentrations in deep groundwater samples from a 150-m-depth well, which is used as a source of tap water in Rokkasho Village, were measured from 2006 to 2011.

The mean ^{3}H concentration in the 5-m-depth well samples was 0.40 Bq L^{-1} (standard deviation, 0.04 Bq L^{-1}; range, 0.36–0.45 Bq L^{-1}). Seasonal variation in the concentrations at each well was small, and almost agreed with annual averaged concentration in the precipitation. The mean ^{3}H concentration in the 25-m-depth well samples was 0.27 Bq L^{-1} (standard deviation, 0.13 Bq L^{-1}; range, 0.05–0.38 Bq L^{-1}). The concentration range for the 25-m-depth wells was wider than that for the 5-m-depth wells. No clear effects of ^{3}H release from the reprocessing plant were observed in these shallow groundwater samples. The ^{3}H concentrations in the 150-m-depth well samples ranged from 0.01 to 0.26 Bq L^{-1} (mean, 0.18 Bq L^{-1}). The source of the ^{3}H in the samples from the 5-m- and 25-m-depth wells, except those in the estuary area, was considered to be global fallout ^{3}H, on the basis of a single-box model with annual averaged data for ^{3}H concentration in precipitation in Japan from 1961 to 2012. However, the ^{3}H concentrations in two samples from a 25-m-depth well in the estuary area and in the 150-m-depth well were lower than the estimated ^{3}H concentration. Groundwater with a relatively long residence time may be mixed in these wells.

This study was performed under a contract with the government of Aomori Prefecture, Japan.

METHOD FOR EVALUATION OF RADIOECOLOGICAL IMPACT TO BIOTA USING THE MONITORING DATA

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The proposed method for evaluation of radioecological impact to natural biota includes the following stages: identification of sources of radiation impact to biota; analysis of monitoring data and model estimates of the radionuclides distribution in the environment; selection of the reference species of natural biota; calculation of the internal and external dose rates to the reference biota organisms; interpretation of results and conclusions. According the ICRP 108 recommendations, the chronic dose rates below the following levels are considered as safe for biota: 0,1 mGy/d for terrestrial vertebrates and pine-tree (Pinus sylvestris); 1 mGy/d for aquatic vertebrates and terrestrial plants (except for pine-tree); 10 mGy/d for all invertebrates and aquatic plants. The chronic dose rates higher than the following levels of exposure to biota are considered as unacceptable: 1 mGy/d for terrestrial vertebrates and pine-tree (Pinus sylvestris); 10 mGy/d for aquatic vertebrates and terrestrial plants (except for pine-tree); 100 mGy/d for invertebrates and aquatic plants. If estimated values of dose rates to reference organisms are lower than safe levels, additional measures of protection of natural biota from ionizing radiation are not required. If values of dose rates are between the safe and unacceptable levels then more research is needed, including the more detailed dose rates assessment, clarification of reference organisms and their habits, decrease of uncertainty of model predictions. If estimated dose rates to biota are higher than unacceptable levels, it is necessary to apply the measures for the radiation protection of the environment.

The method was applied to estimate the radioecological impact of Priargunsky Mining and Chemical Complex (Eastern Siberia, Russia) to the local terrestrial biota. The calculated maximum dose rates to the reference species in this area are the following: terrestrial plants (grass) 0,02 mGy/d; terrestrial invertebrates (warm) 0,007 mGy/d; small mammals Tarbagan marmot 0,12 mGy/d, field vole 0,02 mGy/d. It was concluded that for all reference species dose rates are below or close to the safe level. The major contributor to the doses to biota in the vicinity of the Priargunsky Mining and Chemical Complex is inhalation of ^{222}Rn.

DEPOSITION PATTERNS OF ATMOSPHERIC ^{7}BE AND ^{210}PB IN COAST OF WEST MEDITERRANEAN SEA, MÁLAGA, SPAIN

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The deposition of radionuclides on the ground represents an important factor in environmental radioactivity monitoring and an important input parameter in radioecological models. To predict the long-term radiological consequences of an accidental deposition of the radionuclides to the ground, it is a prerequisite to know the environmental long-term behaviour of these radionuclides and a relatively large number of values are required for statistically meaningful conclusions. Nuclides of the natural decay chains, especially for ^{238}U decay chain, are widely applied into atmospheric research, oceanography and marine geology.

Atmospheric depositional fluxes of ^{7}Be and ^{210}Pb were simultaneously measured in monthly interval for 9 years (from January 2005 to December 2013 at Málaga (4 º28´ 8□W; 36º 43´40□N). Samples were collected monthly in an area of 1 m^2 using a collector that is a slightly tilted stainless steel tray and filling 25 or 50 L polyethylene vessels with bulk deposition. The radionuclides present in all samples are ^{7}Be, ^{210}Pb and ^{40}K appears approximately in 50% of the samples.

The temporal variations of radionuclides exhibit similar seasonal behaviour with low values in winter-autumn months and maximum values in spring-summer months. The time variations of the different fluxes have been discussed in relation to various meteorological factors and the mean values have been compared to those published in recent literature for other sites located at different latitudes. Bulk depositional fluxes of ^{7}Be, ^{210}Pb and ^{40}K have been evaluated for period of measurements. Bulk depositional fluxes of ^{7}Be , ^{210}Pb and ^{40}K varied between 4 and 1779 Bq m^{-2} month^{-1} (annual mean = 1300 Bq m^{-2} year^{-1}), and 1,2 to 102 Bq m^{-2} year^{-1} (annual mean = 156 Bq m-2 year^{-1} and 0,53 to 81 Bq m^{-2} year^{-1} (annual mean = 70 Bq m^{-2} year^{-1}). Data on the atmospheric depositions of radionuclides in Málaga show that the seasonal variation is not uniform from year to year and the amount of rainfall controls the depositional fluxes. A positive correlation has been found between the fluxes and amount of rainfall, the rainfall duration and the number of wet days .A negative correlation has been found with the number of dry days .There is a statistically relationship between ^{7}Be and ^{210}Pb fluxes indicating that removal behaviour from the atmosphere is relatively similar.

CHANGES IN CHEMICAL FORM OF EXOGENOUS IODINE IN SOLID AND LIQUID PHASES OF SOILS COLLECTED FROM FORESTLAND IN ROKKASHO, JAPAN

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While ^{129}I is a cosmogenic natural radionuclide which has long half-life (1.6×10^7 y), spent nuclear fuel reprocessing and atmospheric nuclear weapon testing have been the major sources of anthropogenic ^{129}I in the general environment. The first commercial nuclear fuel reprocessing facility in Japan (Rokkasho, Aomori Prefecture) is undergoing its final testing with actual spent nuclear fuel. A part of the ^{129}I discharged from the facility to the atmosphere is deposited on the land surface. The soil mobility of iodine depends on its chemical form, and this dependence must be elucidated for better prediction of ^{129}I behavior in soil. Here, stable I (^{127}I) was added to soils as I^- or IO_3^-, and temporal changes in the two forms in the solid and liquid phases of the soils were investigated.

An organic horizon (O-horizon) soil and two mineral horizon soils (A-horizon and C-horizon) were collected from a coniferous forest in Rokkasho; the total carbon contents in the three soils were 383, 78 and 10 g kg^{-1}, respectively. Soil samples were added to a NaI or $NaIO_3$ solution and incubated at room temperature for 1 or 14 d. The incubated soils, along with reference materials (NaI, $NaIO_3$ and *p*-Iodophenol), were analyzed by iodine K-edge X-ray absorption near-edge spectroscopy at SPring-8, Hyogo, Japan. The amounts of I^-, IO_3^- and organic iodine (Org-I) in the soils were estimated by linear combination fitting with the reference material data. The I^-, IO_3^- and total iodine concentrations in water extracts of the incubated soils were determined by high-performance liquid chromatography.

After 1-d incubation with the O-horizon soil, 46% and 90% of the I^- and IO_3^-, respectively, were estimated to be Org-I. After 14 d, most of the iodine added to the O- and A-horizon soils was estimated to be Org-I, regardless of the initial form. No changes in the form of iodine in the C-horizon soil were observed.

After 14-d incubation, 91% and 56% of the I^- and IO_3^-, respectively, were extracted from the C-horizon soil with deionized water. The water extraction yields from the O- and A-horizon soils were lower than that from the C-horizon soil regardless of the initial form of the iodine, and the yields decreased with time. The predominant form of iodine in the water extracts from the C-horizon soil corresponded to the spiked form, whereas the iodine extracted from the O- and A-horizon soils was converted to Org-I over time. These results suggest that atmospheric I^- and IO_3^- deposited on the forest floor would be rapidly converted to insoluble Org-I by reaction with soil organic materials.

This study was performed under a contract with the government of Aomori Prefecture, Japan.

FWT AND OBT CONCENTRATION IN PINE NEEDLE SAMPLES COLLECTED AT TOKI, JAPAN (1998-2012)

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In future, nuclear fusion reactor will have large inventory of tritium as fuel. Although tritium as fuel burns in the core plasma and contained into the facility, small amount of tritium will be released as gaseous exhaust and drain water into the environment. The Large Helical Device (LHD) for plasma experiment located in Toki, Gifu Prefecture constructed by National Institute for Fusion Science (NIFS), is now undergoing its plasma experiments for future nuclear fusion generation. Deuterium plasma experiment in LHD is planning now. During deuterium experiments small amount of tritium will be produced from deuterium plasma. To evaluate the tritium effect on the environment precisely, it is important to understand the background concentration of tritium in surrounding environment. Tritium in environmental biological samples consists of free water tritium (FWT) and organically bound tritium (OBT). In this paper, FWT and OBT in pine needles collected at NIFS site and Shiomi Park (SP; Kasahara shiomi no mori) where located 4.5km south of NIFS site were investigated for understanding the regional background tritium concentration in Toki city.

FWT concentration of NIFS site ranged from 0.33 to 0.92 Bq L^{-1} with mean value of 0.61 Bq L^{-1}, and OBT concentrations ranged from 0.41 to 1.10 Bq L^{-1} with mean value of 0.61 Bq L^{-1}. On the other hands, FWT concentration of SP ranged from 0.32 to 0.86 Bq L^{-1}, and OBT concentrations ranged from 0.33 to 0.79 Bq L^{-1}. The results of both sampling points are almost same, and those were gradually decreased year by year. There are no nuclear facilities within 100 km of Toki city. Therefore, concentration level of tritium at Toki city is close to background level in Japan. The apparent half-life of FWT in this period estimated approximately 10 y, those of OBT estimated approximately 12 y. The OBT/FWT ratios are almost approximately 1.0. When non-exchangeable OBT (Nx-OBT) were estimated using other reported parameters, those results were similar to FWT of 1 or 2 years ago.

VARIATION OF ATMOSPHERIC TRITIUM CONCENTRATION IN THREE CHEMICAL FORMS AT TOKI, JAPAN: 2004-2013

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Atmospheric tritium level in the environment was increased by nuclear weapons test in the 1960s. Since then the level has been exponentially decreased to less than 1/100, of which level becomes near the level of before the nuclear test. However nuclear facilities produce local variation and are increased the level. As a future problem, a nuclear fusion reactor will have a large inventory of tritium as fuel which would be estimated larger than few kg. Of course, tritium as fuel is burned in the core plasma and contained in the facility, even though not a small amount of tritium will be released as gaseous exhaust and drain water into the environment. Therefore, the levels of tritium concentration must be measured to secure the environmental safety and to obtain public consent. Environmental tritium concentration in atmosphere, tap and river water, and free water tritium [FWT] and organically bonding tritium [OBT] in pine needles had been measured around the fusion test facility of National Institute for Fusion Science [NIFS] at Toki, because a small amount of tritium will be produced via the Deuterium [D] -D reaction in the fusion test device in near future.

Atmospheric tritium concentrations in three chemical forms such as tritiated water vapor [HTO], tritiated hydrogen [HT] and tritiated methane [CH_3T] had been measured since 2004. Tritium concentrations of HTO, HT and CH_3T were distributed around 2-23 mBq/m^3, 6-11 mBq/m^3 and 0.5-3 mBq/m^3 respectively. The concentrations of HTO and HT seem to have seasonal variation. The variation of HTO is considered to be a cause of the amount of moisture in the air. On the other hands, the cause of seasonal variation of HT is not clear because tritiated hydrogen (HT) would not be discharged from the atomic power stations and tritium atom produced by cosmic ray in the stratosphere would become tritiated water vapor immediately. Then, we focus on the variation of hydrogen molecule in the air. It is well-known that hydrogen molecule in the air has a seasonal variation and is mainly produced via the decomposition of hydrocarbons due to the photochemical reaction. In this presentation, to explore the source of HT, we show the variation of environmental tritium concentration in three chemical forms at Toki and then discuss the cause of seasonal variation of HT comparing with the variation of hydrogen molecule, H_2, in the air.

TRITIUM CONCENTRATIONS IN ATMOSPHERIC WATER VAPOR AND PINE NEEDLES NEAR THE SPENT NUCLEAR FUEL REPROCESSING PLANT AT ROKKASHO, AOMORI, JAPAN

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At the spent nuclear fuel reprocessing plant in Rokkasho, Aomori Prefecture, Japan (40° 57′ 66′ ′ N, 141° 21′ 87′ ′ E), final operation tests with actual spent nuclear fuels are underway, and the plant has released a limited amount of ^{3}H into the atmosphere. We measured ^{3}H concentrations in atmospheric water vapor (HTO) and pine needle samples collected at two sampling points approximately 2 km from the reprocessing plant, to study the effects of ^{3}H release from the plant into the environment. Tritium was released from the plant at a rate of (0.07–1.5) × 1012 Bq month^{-1} (average 6 × 1011 Bq month^{-1}) from November 2007 to October 2008, and at a rate of (1–8) × 1010 Bq month^{-1} (average 3 × 1010 Bq month^{-1}) from November 2008 to December 2009. The HTO concentrations in air in Rokkasho from November 2007 to December 2009 ranged from 0.3 to 1.8 Bq L^{-1}-H_2O. The free-water ^{3}H concentrations in the pine needles in Rokkasho ranged from 0.2 to 7.8 Bq L^{-1}-H_2O. Organically bound ^{3}H (OBT) consists of exchangeable OBT and non-exchangeable OBT (NxOBT). The NxOBT concentrations in the pine needles in Rokkasho ranged from 0.3 to 1.0 Bq L^{-1}-H_2O. We discuss the relationship between free-water ^{3}H and NxOBT concentrations in pine needles and the monthly average atmospheric HTO concentrations.

This work was performed under a contract with the government of Aomori Prefecture, Japan.

ESTIMATION OF LEAD AND OTHER ELEMENTS ELEMENTS IN CONTAMINATED SOIL OF BAGEGA LOCAL GOVERNMENT OF ZAMFARA STATE

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Energy Dispersive X-ray fluorescence (EDXRF) techniques was used to Estimate the lead contaminated soil collected from Bagega processing and mining sites, been one of the villages affected by the epidemic of heavy metals poisoning especially lead (Pb) in Zamfara State, Nigeria. Lead is a radioactive Isotope (radionuclide), a daughter product from polonium-210 as a result of alpha emission. This radionuclide when incorporated into the tissue/organ posed a significant risk to the human body, such as radiation induced syndromes especially to the children. The experiment was carried out at the material science laboratory of the Centre for Energy Research and Training (CERT), Ahmadu Bello University Zaria, Nigeria. The result obtained shows the existence of the following elements at the two sampling sites Si, Pb, Fe, Al, Rb, Ti, K, S, Ca and Cd. The order of concentration in both samples is as follows: Si>Pb>Fe>Rb>Al>Cd>K>Ti>Ca>S.

Key Words: Heavy metals, X-ray Fluorescence, contamination, soil.

ENVIRONMENTAL RADIOACTIVITY OF WATER SAMPLES COLLECTED IN HIGASHI-HIROSHIMA CAMPUS, HIROSHIMA UNIVERSITY, JAPAN

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We have studied environmental radioactivity of water samples in Higashi-Hiroshima Campus, Hiroshima University to check that radioactive nuclides discharged from the radiation facility of Hiroshima University are extremely low compared with regulation values. In the course of the study, we observed an interesting seasonal change of the total β-activity in the sewage sample.1) It was suggested that the total β-activity is mainly due to 40K concentration and the coexisting chemical substances or microorganisms affect the change of total β-activity. On the other hand, brownish yellow microbial mats are growing at the pond and river in Higashi-Hiroshima Campus, Hiroshima University. The microbial mats are produced through biomineralization. In the present study, we investigated the relation between environmental radioactivity and chemical substances in the water samples of Higashi-Hiroshima Campus, Hiroshima University. We also investigated the composition of the microbial mats.

Water samples were collected every month from the river in Higashi-Hiroshima Campus. One is collected at A) upper stream of the microbial mat and the other is at B) lower reaches of the mat. For the comparison, C) the water far from microbial mat is also collected. We measured total β-activity, γ-rays, and metal concentrations, using 2π gas-flow counter, HPGe detector, and ICP-OES, respectively. The concentrations of Fe and Mn in samples A) and B) are relatively high in winter, while the concentrations are relatively low in summer. That is, the concentrations decrease with increasing water temperature, and increase with decreasing temperature. On the other hand, the concentrations of Fe and Mn in sample C) are very low every month. The results suggest that microbial mats become active in summer and adsorb more Fe and Mn in summer. Total β-activity showed an opposite temperature dependence with Fe and Mn concentrations, i.e., the activity increased with an increase in water temperature and decreased with a decrease in water temperature for all samples.

The microbial mats were gathered to take an electron micrograph of the microbial mats. EDX revealed that they contain some iron, aluminum, silicon and phosphorus. We measured iron ion concentrations for ten sample points with and without microbial mats. Iron ion concentrations of some sample points with microbial mats are higher than the concentrations of some sample points without microbial mats. We performed adsorption experiment. The dry microbial mats discharged some potassium ion in the potassium solution, while the non-drying microbial mats adsorbed potassium ion in the potassium solution. The result suggests that the living microbial mats adsorb potassium ion, while dead microbial mats have no capacity of potassium ion adsorption.

In conclusion, we found that the water temperature affects the concentrations of Fe and Mn maybe because of microbial activity. The adsorption phenomenon of potassium to microbial mat changed depending on the activity of microbial mat.

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ANALYSIS OF IODINE-129 IN LEAF VEGETABLE AND SEAWEED SAMPLES BY DRC-ICP-MS AFTER LEACHING WITH TETRAMETHYL AMMONIUM HYDROXIDE AND SEPARATION WITH SOLID PHASE EXTRACTION

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Interference from xenon 129 contained as an impurity in argon carrier gas and hydrides of iodine 127 present in samples is a problem in measuring iodine 129 with ICP-MS. DRC-ICP-MS, which employs a dynamic reaction cell (DRC) technology that can reduce this interference, has dramatically improved iodine 129 measurement. Accordingly, we investigated the use of this DRC-ICP-MS method to analyze iodine 129 in leaf vegetable and seaweed samples. The tetramethyl ammonium hydroxide (TMAH) extraction method was adopted as a means of extracting iodine from samples because of its simplicity and stability relative to the traditional combustion method. Furthermore, leaf vegetable samples were subjected to an additional iodine separation/concentration process, using a solid phase extraction disk to increase the sample quantity for analysis while reducing the volume of solution required for measurement. Analysis of NIST1547 peach leaves and NIST1573a tomato leaves using this method generated values that agreed with the certified values (information) at the 95% confidence interval. In addition, the sample masses of cabbage and Japanese kelp were used for analyses, on a dry basis, 10 g (fresh mass: approx. 170 g) and 3 g (fresh mass: approx. 20 g), and the solid phase extraction method was jointly used to analyze cabbage. The detection limits for iodine 129 in cabbage and kelp were evaluated as 0.018 and 0.23 Bq/kg, respectively, on a fresh mass basis. Compared with the corresponding detection limits when using conventional analysis, these limits were reduced by about 100 times for leaf vegetables and 17 times for seaweed.

GAMMA RAY SPECTROMETRY TO MONITOR THE DISTRIBUTION OF POTASSIUM IN SUGARCANE

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Gamma-ray spectrometry is widely used in elemental analysis to identify and quantify with relatively high precision natural radioactive elements such as ^{40}K and the isotopes of the ^{232}Th and ^{238}U series. Gamma-ray spectrometry is a very accurate technique which allows the measurement of trace elements present in samples with very low concentration [1]. In this work the distribution of potassium in sugarcane has been studied during its growth in two different plantations. In the first one the soil was prepared with natural fertilizers made with the sugarcane bagasse and, in another plantation the soil was prepared with fertilizer NPK-10-10-10. For the measurement of potassium concentration in each part of the plant, gamma-ray spectrometry techniques have been used to measure gamma-rays emitted from the radioisotope ^{40}K. The concentrations of potassium in roots, stems and leaves were measured periodically. The results for sugarcane cultivated in soil with natural fertilizer show a higher concentration of potassium at the beginning of plant development and, over time, there is an oscillatory behavior in this concentration in each part of the plant, reaching a lower concentration in the adult plant [2]. To describe the evolution of potassium distribution in sugarcane it was proposed a phenomenological model assuming that the potassium incorporation rate is proportional to the difference between the element concentration in the plant and a very long term equilibrium value and it is coupled to a resource-limited growth model [2]. On the other hand, the results obtained using fertilizer NPK-10-10-10 shows a lower potassium concentration since the fertilizer provoked a much higher growth rate.

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MEASUREMENT OF ENVIRONMENTAL RADIOACTIVE POLLUTION AT THE ROOF OF A THREE-STORY BUILDING IN LIMA-PERU

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Particles from radionuclides were detected at the roof of a three-story building in the city of Lima-Peru. The detection was made three months after the Fukushima nuclear accident at Fukuoka-Japan. Some radioactive particles contribute to environmental pollution moving around the air, including (^{222}Rn, gas). This paper presents measurements taken over two consecutive years in which the data helped to establish the fluctuations of environmental pollution in the surrounding air. The measurements were made with nitrocellulose detectors (LR-115 type 2), by applying the nuclear track detector technique. Our results provided us with an indicator of the presence ^{222}Rn in the air during different seasons. The use of this technique allows us to obtain and study the tracks generated by alpha particles that are emitted during the decay of ^{222}Rn and their daughters or parents and other radioactive particles. We analyze our measurements results according to the nuclear accident.

COLLABORATION OF LOCAL GOVERNMENT AND EXPERTS RESPONDING INCREASE OF ENVIRONMENTAL RADIATION LEVEL DUE TO THE NUCLEAR DISASTER: 5. VIEWPOINT ON COST AND BENEFIT FOR THE REGULATORY LIMITS ON RADIATION DOSE

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The Fukushima nuclear plant accident released radioactive substances in to the environment. In the result, relatively high radiation dose compared to that prior to the accident has been monitored in a wide range of regions. The Ministry of Health, Labour and Welfare in Japan has regulated limits of radioactivity in food products, e.g., 100 Bq kg^{-1} for agricultural products. However previous works have shown that there exists no explicit threshold dose of whether to induce leukemia and other cancers. It is therefore necessary to evaluate the limits from other points of view such as cost-benefit. In this paper we investigate cost and benefit with respect to regulatory limits on radiation dose by means of data of radioactivity in agricultural products grown in Kashiwa city. Especially we derive a benefit to avoid a loss of life expectancy as the benefit of the regulation. In order to obtain the benefit to avoid a loss of life expectancy, the value of statistical life (VSL) must be provided. In this analysis, we use VSL amounts of 2.26 million JPY, which has been shown in Cabinet Office (2007). In addition, Oka (2012) considers a disposal fee of agricultural products as the cost of the regulation. However the cost of the regulation also includes a survey cost of the radiation dose with respect to agricultural products. Thus the cost of the regulation, which is considered in this analysis, composes of the disposal fee of agricultural products and the survey expense for radioactivity in food products. By means of these values of benefits and costs, we calculate limits of radioactivity of each agricultural products for various ages. We furthermore discuss the efficiency for the current limit of radioactivity by comparing the value to the limit which is obtained from this analysis.

MEASUREMENT OF NATURAL RADIOACTIVITY, RADON EXHALATION RATE AND RADIATION HAZARD ASSESSMENT IN INDIAN CEMENT SAMPLES

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Building materials are the main source of radon inside the dwellings. Because of low level of radon emanation from these materials, long term measurements are needed.Radiation doses vary depending upon the concentrations of the natural radio nuclides like ^{226}Ra, ^{232}Th and their daughter products and ^{40}K, present in cement samples. These radio nuclides pose exposure risks due to their gamma ray emission and internally due to radon and its progeny that emit alpha particles. In the present study, radon exhalation rate and the activity concentration of ^{226}Ra, ^{232}Th and ^{40}K radionuclides in cement samples fromthe Aligarh region (U.P.), India have been measured by ‘‘Sealed Can technique’’ using LR-115 type II detectors and a low level NaI (Tl) based gamma ray spectrometer, respectively (Mahur et al., 2008)..

Radon activities are found to vary from 80.0 ± 12.3 to 320.0 ± 24.7 Bqm^{-3}. Surface exhalation rates in these samples vary from 30.6 ± 4.5 to 115.1 ± 8.8 mBq m^{-2} h^{-1} , whereas mass exhalation rates vary from 1.2 ± 0.2 to 4.4 ± 0.3 mBq kg^{-1}h^{-1}..

Activity concentrations of naturally occurring radionuclides (^{226}Ra, ^{232}Th and ^{40}K) were also measured in these cements samples. Activity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K vary from 9 ±5 to 28 ± 14 Bq kg^{-1}, 21 ± 13 to 43 ± 15 Bq kg^{-1} and 280 ± 145 to 573 ± 147 Bq kg^{-1}respectively. From the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K, radium equivalent activity (Req) was calculated and found to vary from 58.9 to 109.1 Bq kg^{-1}.Results will be discussed in the light of various factors.

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DISTRIBUTION OF NATURAL (^{238}U, ^{235}U, ^{226}RA, ^{232}TH, ^{40}K) AND ARTIFICIAL (^{137}CS) RADIOACTIVITY IN SOIL SAMPLES IN TAIF REGION, SAUDI ARABIA

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In the present study, the concentration of naturally occurring radionuclides (^{238}U, ^{235}U, ^{226}Ra, ^{232}Th, ^{40}K) and artificial (^{137}Cs) were measured using high resolution hyper pure germanium spectrometers. Soil samples were collected from more than forty location from Taif region in the Kingdom of Saudi Arabia. The coordinates of all locations were determined by the Global Positioning System (GPS) for any future investigation. Gamma- ray dose rates have been measured in the same locations, from where soil samples were collected and the measured values are given together with those dose rates calculated from the measured concentrations of natural radioactivity in soil. The results of measurements will serve as baseline data and background reference level for Saudi Arabian.

^{226}RA AND ^{210}PO CONCENTRATION IN DRINKING WATER OF CAUVERY RIVER BASIN SOUTH INTERIOR KARNATAKA STATE, INDIA

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The naturally occurring radionuclide ^{210}Po arising from the ^{238}U decay series, provide a considerable contribution to the radiation exposure to humans. It is a highly toxic alpha emitter that is rarely found in groundwater. Drinking water samples collected from Cauvery river basin of south interior Karnataka State were analyzed for the activity of ^{210}Po using radiochemical techniques. The estimated concentration of 210Po was found to vary from 2.0 to 78.9 mBq.L^{-1} with a median of 12.6 mBq.L^{-1}. The estimated values for the study area were well below the guidance value of 100 mBq.L^{-1} by the World Health Organization. ^{226}Ra concentration in water samples is measured using Emanometry technique. ^{226}Ra concentration in drinking water samples ranges from 1.85 to 81.06 mBql^{-1} with the mean value of 36.14 mBql^{-1}. The calculated average annual effective doses from ingestion of water and inhalation of this radionuclide escaping from water was 295.51 μSv. The total dose estimated is less than the recommended value by ICRP.

NATURAL RADIOACTIVITY AND EFFECTIVE DOSE DUE TO THE BOTTOM SEA AND ESTUARIES MARINE ANIMALS IN THE COASTAL WATERS AROUND PENINSULAR MALAYSIA

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Malaysia is among the countries with the highest fish consumption in the world and relies on seafood as a main source of animal protein. Thus, a study was conducted to determine the concentrations of natural radionuclides as well as artificial radionuclides that might be released from the Fukushima nuclear accident on 2011 in some bottom sea marine animals such as molluscs, squid (Teuthida), shrimp (Caridea), and some green mussel (Perna Viridis). Fresh samples were collected from several places of coastal waters around peninsular Malaysia; the radionuclide concentration being determined by using HPGe ɤ-ray spectrometer. Highest activity of ^{40}K was found in green mussels collected from Pantai Remis with 79.82 ± 3.76 Bq kg^{-1} , while for ^{232}Th and ^{238}U, the highest radionuclide concentration were found in shrimp with 2.16 ± 0.32 Bq kg^{-1} and squid with 4.20 ± 1.37 Bq kg^{-1} respectively, both collected from Tok Bali area. This study indicates that marine animals and/or waters of Tok Bali area is the most contaminated compared to the other locations. Results from these studies are useful for future references.

RADON LEVELS AND DOSES IN DWELLINGS IN TWO VILLAGES IN KOSOVO, AFFECTED BY DEPLETED URANIUM

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The radon (^{222}Rn) activity concentration in 15 dwellings in the Planej village and 10 dwellings in the Gorozhup village has been measured with the aim to complement the national radon survey and to compare the results of two different measurement techniques.

The radon concentration has been measured in winter and spring using alpha scintillation cells and in winter, spring and summer by exposing solid-state nuclear track detectors. Both methods gave similar results. Radon concentrations in both villages were similar, ranging from 82 to 432 Bq m^{-3}; the value of 400 Bq m^{-3} was exceeded only in two dwellings. The resulting annual effective doses ranged from 1.78 to 6.40 mSv, with the average values of 3.28 mSv in the Planej village and 3.87 mSv in the Gorozhup village. The area included in the study was hit by depleted uranium projectiles during the North Atlantic Treaty Organization bombing in 1999. Although no impact of depleted uranium on radon levels has been observed, these two villages were selected in order to diminish general concern among residents.

DISTRIBUTION OF ARTIFICIAL RADIONUCLIDES IN AGRICULTURAL SOIL AT DIFFERENT PROFILES

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Artificial radionuclides have been released to the environment by several types of nuclear activities, including atmospheric nuclear weapon tests and nuclear accidents. Global fallout of fission products in the 1950s and 1960s involved deposition of ^{90}Sr and ^{137}Cs, as the most important artificial radionuclides. Besides the total deposited amount, the radiological importance of artificial radionuclides is determined by their radiotoxicity and radiation type, bioavailability and behaviour within the food-chain.

The soil samples were collected in the spring season of 2013 at the experimental field Radmilovac (property of the Faculty of Agriculture, University of Belgrade) in the Republic of Serbia. ^{90}Sr activity concentrations in these samples were determined using the radiochemical analytical method, while ^{137}Cs activity concentrations were determined by gamma spectrometry.

Artificial radionuclides, ^{90}Sr and ^{137} Cs were detected down to 30 cm depth of agricultural soil. ^{90}Sr activity concentration in soil samples from depth 0-15 cm and 15-30 cm ranged from 0.52 to 1.14 Bq/kg and between 0.31 and 1.34 Bq/kg, respectively. Content of ^{137}Cs activity concentration ranged from 25 to 30 Bq/kg for 0-15 cm depth of soil and from 14 to 31 Bq/kg for 15-30 cm depth of soil. Based on these results, distribution of ^{90}Sr and ^{137}Cs in surface layer of soil for area of the profile 10×10×15 cm was calculated. The obtained results ranged from 0.055 to 0.14 kBq/m^2/15 cm and from 2.62 to 4.77 kBq/m^2/15 cm for ^{90}Sr and ^{137}Cs, respectively. Vertical migration of these radionuclides is a complex process which depends on many factors which are reflected by nonuniform distribution of ^{90}Sr and ^{137}Cs radioactivity. The obtained results confirmed literature data concerning the range of the vertical migration of ^{90}Sr and ^{137}Cs.

Keywords: *Distribution ^{90}Sr and ^{137}Cs; agricultural soil.*

ORAL PRESENTATIONS

A DISCUSSION ON NORM GUIDELINES – PROPOSED REVISIONS NEEDED FOR PRACTICAL USE

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Canada is one of the leading mining countries and one of the largest producers of minerals and metals in the world. Canada has had a long involvement with naturally occurring radioactive materials (NORM), mainly because of mining and processing of mineral ores. The Canadian Nuclear Safety Commission (CNSC) has legislative control of nuclear fuel cycle materials, and man-made radionuclides. The handling and disposal of NORM in Canada are exempted from CNSC jurisdiction except for the transport, import and export of NORM. In principle, NORM management is regulated by the provincial and territorial governments. The first edition of the Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials was published by the Canadian Federal Provincial Territorial Radiation Protection Committee in 2000. The guidelines set out principles and procedures for the detection, classification, handling and material management of NORMs in various forms, and led to increased consistency in the interpretation and application of NORM-related radiation safety standards across Canada.

In the intervening fifteen years, the radiological protection system has evolved. International awareness of NORM as a potential source of risk to workers, members of the public and the environment has increased significantly in recent years. Due to the prevalence of NORM, many NORM related issues have been encountered by companies or individuals who are not commonly considered as a NORM industry, such as fish hatcheries, construction industries, storage facilities or even landlords. In many cases, people are confused regarding the interpretation and application of current guidelines. To address these new challenges, the guidelines need to be updated. In this paper, possible revisions to the NORM Guidelines are proposed and discussed.

NATURAL RADIOACTIVITY ASSOCIATED WITH ABRASIVE BLASTING, A CASE STUDY

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A baseline radiological survey of an area of land indicated levels of gamma radiation significantly greater than the area's background radiation, and greater than observed in historic surveys carried out at the same location. Investigation revealed that the radiation was associated with a type of grit used for abrasive blasting. The abrasive blasting material was out of specification with that normally used, and it left a legacy that required remediation.

This case study provides information on the detection, measurement and identification of the abrasive grit, its use and application, and measures taken to prevent recurrence and remediate the impacted area.

RADIATION IMPACT ASSESSMENT OF NATURALLY OCCURRING RADIONUCLIDES USING GAMMA RAY SPECTROSCOPY

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The natural radioactivity levels in soil samples of Una district of Himachal Pradesh, India have been determined. Bottom sediments from 13 locations were collected to determine ^{226}Ra, ^{232}Th and ^{40}K using a high-resolution gamma spectrometry system. Direct determination of ^{238}U using semiconductor γ-ray spectrometer is very hard because ^{238}U does not have intensive γ-rays (lines) of its own. But it has several daughter products which have more intensive lines and activities equal to those of their parents in the state of secular equilibrium. The most intensive energies, used to determine ^{238}U contents, either come from ^{226}Ra and its progeny or from ^{232}Th. That is why the measurement of concentration of ^{226}Ra and ^{232}Th is important for the radiation risk assessment. The results have been compared with worldwide recommended values. Radium equivalent activities were calculated for the samples to assess the radiation hazards arising due to the use of these soils in the construction of dwellings. The absorbed dose rate calculated from activity concentration of ^{226}Ra, ^{232}Th and ^{40}K are well within the recommended action levels. The calculated values of external hazard index (Hex) for the soil samples are less than unity.

ASSESSMENT OF GAMMA DOSE RATE IN DWELLINGS DUE TO DECORATIVE STONES

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With the improvement of public living standards, more and more granites and other types of stones are used as decorative materials in dwellings, and the radiation exposure to dwellers has caused a widespread concern. In this study, for assessing the enhanced external exposure to dwellers more accurately, the room models with different geometric and decorative conditions were built, and the 3-D distributions of indoor gamma dose rates were computed with the Monte Carlo simulations, and the simulation results were testified throughout measuring the accumulative doses with thermoluminescent dosimeters (TLDs) in a model room. The simulation results showed that if the contents of radionuclides in decorative stones were higher than those in main building materials, the enhancement of indoor gamma dose rates increased with not only the decorated areas, but also the decorated thicknesses in the same room. For the decorative stone with a thickness from 1 cm to 3 cm, the increase of gamma dose rate was approximately linear. The gamma dose rate also increased with the area of decorative stones, but the increasing trend slowed down. For the same decorative stones, the smaller the room, the larger the increase of gamma dose rate. In the model room, the measured accumulative gamma doses were consistent with the simulation results within ±10%. The above results show that the increase of indoor gamma dose rate depends not only on the radionuclide contents, but also on the area and thickness of the decorative stones as well as the room size. The simulation method established in this study can estimate the enhanced external exposure to residents due to decorative stones more accurately, and it provides a theoretical basis for revising the limit standard on radionuclide contents in stone materials.

DETECTOR TIMEPIX FOR AN IN-SITU MEASUREMENT IN NORM INDUSTRIES

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The detector Timepix is presented as a lightweight dosemeter providing an information about concentration of short and long lived radon progenies and other radioisotopes of uranium/thorium decay chains. In order to use the detector in the environment we developed a new mechanical construction used for gas filtering. One-grab sampling method on open face filter is used for estimation of concentration of short lived radon progenies. Spectrometric information is also used for identification and concentration estimation of other radioisotopes. An identification of hotspots is also studied.

RISK OF NATURAL RADIATION LEVEL INCREASE IN THE NORTHERN PART OF NIGER REPUBLIC DUE TO URANIUM MINING AND OTHER NORM INDUSTRIES

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Niger is one of the world largest uranium producers with three uranium mining companies in activity: Société des Mines de l'Aïr (SOMAÏR), Compagnie Minière d'Akouta (COMINAK), Société des Mines d'Azelik (SOMINA). Furthermore, a new uranium mine is in the development stage (Mine of IMOURAREN), other uranium mining projects are now in the feasibility study stage (GoviEx) and currently there are 57 uranium exploration permits issued. Based on 2012 data from the World Nuclear Association, Niger with a production estimated of 4,667 tons of uranium occupied the fourth position amongst world uranium producers, after Australia (6,991 tons), Canada (8,999 tons) and Kazakhstan (21,317 tons).

Uranium mining activities started in Niger in the 1950's even before the independence. According to several reports, the tailings generated by the exploration, mining, and processing of uranium ore enhanced considerably the radioactivity levels in the uranium mining areas (in soil, food, water and air) which contributes to increase the radiation exposure of people living in an area with already high levels of natural radiation background.

Other than the mining and milling of uranium, other NORM (Naturally Occurring Radioactive Materials) industry sectors, such as oil and coal, may contribute to the radiation exposure of Niger population. The coal power plant which supplies energy to all the uranium mining companies of Niger was established in 1981, and oil production started in 2011 in Niger. However, the radiological impact of these industries was not assessed yet and there is also a lack of regulation on radiation safety applicable to these industries.

The development of these industries urges the need to implement measures in order to avoid, reduce or minimize the potential impacts of ionizing radiation on the people and the environment and, at the same time, to ensure that negative impacts are mitigated and positive ones enhanced and, if possible, remedy significant adverse effects. Unfortunately, in order to be able to monitor such impacts, there is lack of specialized monitoring equipment and infrastructures in the country. Radiation dose assessments for these activities are lacking and suitable regulations and disposal facilities for the management of radioactive waste had not yet been established. A start is now taking place with the support of International Atomic Energy Agency (IAEA) Technical Cooperation projects and training of technical staff.

INVESTIGATING THE NORMS LEVEL ASSOCIATED WITH ABANDONED MINE SITES IN MISTALI-JOS, NIGERIA

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The decades of commercial tin mining operations have created a legacy of derelict landscapes and impoverished lands in many parts of plateau state Nigeria. This paper seek to identify and quantify prominent gamma emitting-NORMs (^{40}K, ^{238}U and ^{232}Th) associated with historical mine sites in Mistali-Jos, a suburb of Plateau state capital city, Jos. Soil samples were collected from 13 abandoned mine sites in Mistali-Jos, for gamma spectroscopy analysis. A laboratory based γ-ray spectrometry with NaI(Tl) detector at the Centre for Energy Research and Training, Ahmadu Bello University Zaria, Nigeria was employed to carry out analysis of the soil samples. Results of this investigation show that the values of activity concentration due to ^{40}K, ^{238}U and ^{232}Th range from 715.93±7.72 – 1206.79±1.93, 95.46±1.68 – 241.10±9.39 and 319.82±1.85 – 714.15±5.27 Bq.kg^{-1} respectively, while absorbed dose rate in the soil samples range from 29.85±0.32 – 50.32±0.08, 40.10±0.78 – 111.39±4.34 and 193.17±1.12 – 431.35±3.18 nGy.h^{-1} respectively. The total average absorbed dose rate of the soil samples collected is 288.76 nGy.h^{-1} and the estimated annual effective dose for the study area range from 0.36 – 0.72 mSv.y^{-1}, with an average annual effective dose of 0.49 mSv.y^{-1}. This shows that there is no radiological burden on the environment at the moment.

DESIGN AND RESULTS OF THE RADIOLOGICAL IMPACT ASSESSMENTS OF ALL SPANISH COAL-FIRED POWER PLANTS

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The design and results of the R&D project where the radiological impact of all the 17 Spanish operating coal-fired power plants have been assessed are presented in this paper.

The project was the response of that industry to the publication of a recently published Spanish law: the Royal Decree 1439/2010, which amends the Spanish Regulation on Protection against Ionizing Radiation of 2001 (RD 783/2001). This law force to the owners of the radiological activities, where natural radiation sources exist, to conduct every study needed to determine whether exist a significant increase to the exposure of the workers or to the members of the public, which can not be disregarded from the point of view of radiation protection.

For that reason, all the Spanish coal-fired power plants decided to assess the radiological impact to their workers and to the members of the public, following the newly published regulatory guidances. The studies were performed following the document ""NORM Industries Action Protocol: Electricity generation by burning coal"", developed by the authors, where the graded approach was used to determine the basis for carrying out screening assessments in this kind of installations, based on the experience from a former project where the 4 major Spanish coal power plants were evaluated in detail.

The assessments were carried out based on the calculation of total effective dose received by workers and the public as a result of the range of operation of the plants, including the range of activity concentrations which could be found internationally in the coal. The radiological criteria to determine whether the work activity is exempt from regulatory control or not, was defined by the Spanish regulatory body (Nuclear Safety Council or CSN), being 1 mSv a-1 for workers and 0.3 mSv a-1 for members of the public, which are expressed in terms of effective dose over the natural radioactive background. Also the activity concentrations in materials were compared with the levels of exemption and clearance established in Spain, Europe and by the International Atomic Energy Agency (IAEA) for large amounts of materials for the natural decay chains of 238U, 235U and 232Th and 10 Bq g-1 for 40K.

NORM MANAGEMENT IN CONVENTIONAL WASTE DISPOSALS

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Naturally Ocurring Radioactive Materials (NORM) are generated in huge quantities in several NORM industries, and their management were formerly carried out under considerations of industrial non radioactive wastes. As the concentration of non radioactive toxics in several of those materials is relatively high, they were usually treated as toxic materials. This implies that the materials must be previously conditioned using conventional methods and that the waste disposals were prepared to isolate the toxics from the environment for long periods of time. Spanish regulation for these conventional toxic waste disposals includes conditions that would therefore assure adequate isolation.

After the 96/29 European Directive (the European BSS), radiological implications on NORM industries and their residual materials must be considered. One option that can be considered for the disposal of NORM with activity concentrations above the unconditional clearance level is the use of the same hazardous waste disposals. The recently published revision of these BSS (The 59/2013 Directive) establish the base for using conventional management options for these materials.

In this work the radiological implications on the management in these disposals of NORM wastes are presented, assessing the radioactive content over IAEA clearance levels which could be managed in these conventional waste disposals. Also generic dose assessments for workers and for the public are presented, with special attention to possible variations in the way of dealing with these wastes in Europe and focusing in Spanish situation. These calculations could be used as a base for allowing the continuation of the use of this type of management. Finally a discussion on the different options for performing specific assessments is included.

FEASIBILITY STUDY FOR THE ASSESSMENT OF THE EXPOSED DOSE WITH TENORM ADDED CONSUMER PRODUCTS

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The public members could be significantly exposed by using the consumer products containing a Technically Enhanced Naturally Occurring Radioactive Material (TENORM). The law, Act on Safety Control of Radioactive Rays around Living Environment, has implemented to prevent the radiation hazard in Korea. However, the procedure to monitor the exposed dose with the usage of TENORM added consumer products around living environment. The activities of gammas and alphas/betas emitted from natural radionuclides in the five types of paints, advertised as releasing anion, were measured with high-purity germanium detectors and low background alpha/beta counting system, respectively. Under the assumption that Korean stay in the painted room of 4 m (length) x 3 m (width) x 2.8 m (height) for 9 hours 12 minutes per day, the organ dose and effective dose were calculated with the Monte Carlo method using the MCNPX code and the International Commission on Radiological Protection (ICRP) reference phantom. Our results show that uranium and thorium series mainly including Pb-214, Pb-212, and Bi-214 were measured with K-40 over the five kinds of paints and their activities were 0.07 – 23.24 Bq/g. In the calculation of the organ dose, gammas were considered due to the short range of alphas and betas. The annual effective doses with the five paints were evaluated as less than 0.4 mSv/year (<public dose limit of 1 mSv/year). The procedure proposed in this study demonstrated the potential in the exposed dose assessment with the usage of TENORM added consumer products and it could be used for the safety control in Korea

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POSTER PRESENTATIONS

SEPARATION OF NATURAL RADIONUCLIDES IN TENORM PHOSPHOGYPSUM

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Natural radiation is the major source of human exposure to radiation by which many products and processes, obtained from natural raw materials with higher levels of radiation, eventually pose a risk to the health of the population. Based on such knowledge, this work presents a study of phosphogypsum from fertilizer industries, which may contain toxic elements such as heavy metals and natural radionuclides. Thus, the provision and use of phosphogypsum may develop environmental disturbances and imbalances regarding natural radiation exposure that must be studied [1,2]. Phosphogypsum is a byproduct of the chemical reaction between sulfuric acid and phosphate rock to produce phosphoric acid (H_3PO_4), which is mostly used as feedstock for the production of phosphate fertilizers. This material is considered a Technologically Enhanced Naturally Occurring Radioactive Material – TENORM. For every ton of phosphoric acid, 4-5 tonnes of phosphogypsum are produced, which accumulate over time and represent a major environmental pollutant to the manufacturers. The interest in reducing the amount of natural radionuclides present in phosphogypsum led the research for efficient and economically viable solutions to the use of this material. In this work, we measured the natural radiation present in some stages of the process that generates phosphoric acid and phosphogypsum waste. The samples were provided by Vale Fertilizantes S.A. The natural radiation was characterized by gamma-ray emission of the isotopes of the ^{226}Ra and ^{232}Th radionuclides series [1,2]. The detection system is composed by a NaI(Tl) scintillation detector placed inside a lead shield. A ^{60}Co source was used for energy calibration. For activity calibration, ^{238}U and ^{232}Th IAEA reference materials were used. This study shows the importance of the phosphogypsum treatment, which was analyzed through samples of posphogypsum in the main stages of phosphoric acid production: phosphate rock, phosphate concentrate, and phosphogypsum. A crystallization process was used to treat chemically the phosphogypsum, which resulted in reducing the content of natural radionuclides. This process allows the separation of the initial phosphogypsum material into two parts, the phosphogypsum and another with concentrated radioactive material. As a result, the highly concentrated radioactive part represents only 20% of the initial volume. The concentration of the natural radionuclides in the phosphogypsum part, after this process, is below the detection limits of the gamma-ray spectrometry system, indicating this part has a much smaller concentration of natural radioactive elements. This result enables greater use of this clean phosphogpsym as gypsum and allows a large reduction of the storage area of the TENORM part.

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NATURAL RADIOACTIVITY FROM BRAZILIAN SANDS

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In this work the distribution of natural radiation from Brazilian sands using gamma-ray spectrometry was studied. In most of the regions studied the dose due to external exposure to gamma-rays, proceeding from natural terrestrial elements, are within the values 0.3 and 1.0 mSv/year, typical range indicated by the United Nations Scientific Committee on the Effects of Atomic Radiation. The present work investigated more than fourteen Brazilian beaches and a sandy region near the Brazilian coast in order to analyze the dose from total terrestrial external radiation. We have found high total external radiation in Preta Beach in Ilha Grande, Rio de Janeiro, Preta Beach and Sahy in São Paulo, Itacaré in Bahia, exceeding more than twice the international average value for external exposure due to natural elements. The values of the external hazard index determined from the sand radioactivity are less than the recommended safe levels for most of the studied samples. Energy-Dispersive X-Ray Spectroscopy (EDS) microanalysis showed that this high external radiation is related to the presence of zircon and monazite, which commonly carry traces of uranium and thorium.

THE IMPACT OF THE EXTENSIVE USE OF PHOSPHATE FERTILIZERS ON RADIOACTIVITY LEVELS IN FARM SOIL IN TANZANIA

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The use of different types of fertilizers including phosphates in agricultural activities in Tanzania is increasingly becoming important in recently years. The practice is motivated by the Government through fertilizer subsidies made all over the country for the purpose of bringing green revolution. The most commonly used phosphate fertilizers in Tanzania are single superphosphate (SSP), di-ammonium phosphate (DAP) and triple superphosphate (TSP), which are imported from outside the country, as well as a local phosphate fertilizers from Minjingu phosphate deposits in Arusha which is a raw phosphate rock crushed into powder and granules. However, despite the enormous benefits derived from the use of fertilizer, literature has shown that phosphate fertilizers are normally associated with elevated concentrations of ^{238}U, ^{232}Th and their progenies such as ^{226}Ra and ^{228}Ra. On top of that the Minjingu phosphate rock is reported to contain higher activity concentration of ^{238}U and its progenies (~ 4000 Bq/kg) than many phosphate rocks reported elsewhere. Therefore, there is a need to assess the activity concentration of radionuclides associated with phosphate fertilizers in farm soil. In this study samples of soil from farms in Iringa rural were analysed for radioactivity using gamma ray spectrometry of the Tanzania Atomic Energy Commission in Arusha Tanzania.

The study was conducted in Iringa rural because it is one of the districts with a combination of farms that make extensive use of phosphate fertilizers and farms that grow similar vegetables organically. The aim of this work was to dertermine the radioactivity levels in soil associated with the use of phosphate fertilizer in farming. The informations obtained can be used by the authority to evaluate the radiological risks associated with the use of phosphate fertilizers in agricultural activities.

ASSESSMENT OF NATURAL AND ARTIFICIAL RADIOACTIVITY IN THE SEDIMENTS AND FISH OF BONNY ESTUARY, NIGER DELTA, NIGERIA

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There is widespread contamination of environment of the Niger Delta, which may include enhanced background levels of natural radioactive materials (NORM) due to oil production and rapid urbanization activities. Sediments and seafood from the Bonny estuary, Niger Delta were collected for the purpose of determining baseline data on artificial and natural radioactivity and estimation of effective dose to the public due to ingestion of seafood from the study area. The highest and lowest activity concentrations were reported for ^{40}K and ^{137}Cs in both sediments and fish samples of the Bonny estuary. There was some evidence of spatial variability in the 40K and ^{137}Cs data, with the latter being the likely result of dredging. Other radionuclides were not significantly different between sites impacted by industrial activities or not. Activity of radionuclides measured in the sediments of the study area were higher than reported elsewhere in the Niger Delta and Nigeria and higher than reported global averages by UNSCEAR. The total highest activity concentration in all fish species of gamma emitting radionuclides was observed for ^{40}K, followed by ^{238}U, ^{232}Th and ^{226}Ra respectively while ^{137}Cs had the lowest activity concentration. However, ^{210}Po activities were the most important in terms of dose contribution. Consumption of molluscs at typical rates could result in doses exceeding 1 mSv y^{-1}. Although this baseline data may not be conclusive on prevailing trends in radioactivity in the study area, higher consumption rates of the species studied may have public health consequences due to effects of low dose ionising radiation.

DISTRIBUTION OF NATURALLY OCCURRING RADIONUCLIDES IN SOME NATIVE VEGETABLES AND FRUITS IN THE SOUTHERN, THAILAND

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The aim of this study was to provide baseline data information of natural radioactivity in vegetables and fruits produced and consumed locally in the areas of potential nuclear power plant sites in Thailand. Four provinces (Prajuab-Kirikhan, Chumphon, Surat-Thani, and Nakhon-Si-thammarat) were selected for collection of native vegetables and fruits samples, together with their corresponding soils. The activities of ^{226}Ra, ^{228}Ra, ^{40}K, and ^{210}Po were determined in vegetables, fruits and soil samples. The obtained results of ^{226}Ra, ^{228}Ra and ^{210}Po for all vegetable and fruit samples are in the range of 0.6-20 Bq kg^{-1}, 0.5-21 Bq kg^{-1}, and 0.3-101 Bq kg^{-1}, respectively which are much lower than those obtained for their corresponding soils, while the average concentrations of ^{40}K in all samples are approximately identical.

NATURAL RADIOACTIVITY FROM BUILDING MATERIALS IN SPAIN

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The industrial construction sector is very important in Spain. Building materials used in this industry are sources of radiation from natural radionuclides they contain. The studies about this subject have increased notably during last years. This, probably, can be associated with the increase interest from natural radiation radiological risk on indoor exposure.

The evaluation of environmental impact caused from the radionuclides of building materials is made by the Nuclear Safety Council (C.S.N.), CIEMAT and some radioactive environmental laboratories. The University of Malaga is developing the ARMAC Project to analyze the composition and the radioactivity of the materials used in building. The samples were supplied by manufacturers and it has been made a physic-chemical characterization of the samples received. The chemical composition of the samples of cement, brick, ceramic and roofing tile has been made using ICP-MS and XRPD. XRPD is a powerful tool for material characterization in general, and cements materials in particular. The use of the Rietveld method has allowed quantifying the clinkers and cements measured by laboratory x-ray powder diffraction (LXRPD) giving their accurate phase assemblage. The results of these analyze shows near 72 different elements. The higher concentrations are of Na, K, Ca, Al, Fe and Si. Cement and concrete samples were analyzed by ICP-MS using a NexION 300D (Perkin Elmer) with a dual-channel universal cell, triple cone interface, quadrupole deflector, concentric nebulizator and cyclonic spray chamber. Samples were previously acid digested by a microwave-assisted digestion system (Anton Paar).

The concentration of the natural radioactivity in the selected cements and ceramics were conducted with a coaxial ReGe detector. The energy an absolute efficiency calibration of the spectrometer was made using a sample certificated by IAEA-312 and IAEA-385. Furthermore, for quality control for gamma-spectrometric analysis we participated in international and national intercomparison analyses.

The activity concentrations are ranged between 67.4, 29.1 and 267.1 Bq/Kg from ^{226}Ra, ^{232}Th and ^{40}K respectively from samples of Portland cements.

To compare the radiological effects of the materials used in the building which contain ^{226}Ra, ^{232}Th and ^{40}K, a common index is required to obtain the sum of activities and according to RP 112 the absorbed dose in air can be calculated. Some indices dealing with the assessment of the excess gamma radiation arising from building materials such as external and internal hazard indices and gamma –concentration indices, In this study the gamma –index is calculating as proposed by the European Commission $I\gamma = I$ (CRa, CTh, CK) where CRa, CTh and CK are the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in Bq.kg^{-1}, varying between 0.17 and 0.29.

ENVIRONMENTAL MONITORING AFTER REMEDIATION ACTIVITY AT OLD URANIUM MINE SITE

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This paper illustrates environmental monitoring results in and around an old uranium mine site remediated by the Japan Atomic Energy Agency (JAEA). The site remediated is the waste rock site located on the steep slope of a hill about 1.5 km upstream from a residential area along a main ravine. Major remedial action was performed by covering the waste rock yards with weathering granite soil. Radon exhalation rate, radon concentration and gamma-ray dose rate are mainly discussed. These measurements were carried out at about 30, 50 and 3300 points, respectively. These results prove that soil cover keeps its function over 5 years. In addition, environmental impact from the site has been negligible before the action.

AN INVESTIGATION OF RADON EXHALATION RATES, NATURAL RADIOACTIVITY AND RADIATION EXPOSURE IN FLY ASH FROM THERMAL POWER PLANTS, INDIA

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Fly ash has found wide applications world-wide for cement and sand replacement, in pre-mixed concrete for the manufacture of blended fly ash-Portland cement, aerated concrete, fly ash clay bricks and blocks, for road making and as a filler in asphalt etc. In India Coal based thermal power plants contribute about 72% of the total power generation. Indian coal has high ash content with ~ 55-60 % ash and it is estimated that ~100 million tons of fly ash is produced per annum. Due to considerable economic and environmental importance, the collected fly ash has become a subject of world wide interest in recent years because of its diverse uses in construction activities.

In the present study, an attempt has been made to measure radon exhalation rate through 'Can' technique" (Mahur et al., 2008) using SSNTD and ^{238}U, ^{232}Th, and ^{40}K activity concentrations by gamma ray spectroscopy from the fly ash collected from the National Thermal Power Corporation (NTPC), Dadri (Uttar Pradesh) and Bandel Thermal Power Station (BTPS), Tribeni (West Bengal) in India to assess the radiological impact.

In the fly ash samples from NTPC, Dadri the radon activity is found to vary from 1797.1 ± 51 to 3778.6 ± 73 Bq m^{-3} with an average value of 2745.3 ± 63.1 Bq m^{-3}, whereas radon exhalation rate were found to vary from 24.9 ± 0.7 to 52.3 ± 1.06 mBq kg^{-1} h^{-1}. The samples from BTPS, Tribeni radon activity is found to vary from 794.6 ± 34 to 1414.3 ± 45 Bq m^{-3} with an average value of 1055.5 ± 39 Bq m^{-3}, whereas radon exhalation rate varies from 11.0 ± 0.4 to 19.6 ± 0.6 mBq kg^{-1} h^{-1}.

From the activity concentrations of ^{238}U, ^{232}Th and ^{40}K in the fly ash samples from BTPS, Tribeni the absorbed gamma dose rate varies in the range 92.3 to 173.0 nGyh^{-1} and Activity concentration index 'I' varies from 0.72 to 1.38 with an average value of 1.4. The external annual effective dose rate varies from 0.11 to 0.21 mSv y^{-1}. Results will be discussed.

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GAMMA DOSE RATE EXPOSURE IN A URANIUM MINING/MILLING AREA IN GUANGDONG PROVINCE, CHINA AND ITS RADIOLOGICAL IMPLICATIONS TO WORKERS

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With attempt to investigate the radioactivity level and its influencing range, large scale in situ measurements of gamma dose rate exposure in a uranium mining/milling area in Guangdong province, China were conducted. The measurement sites covered miming area, milling area, uranium tailings area and downstream area. A variety of objects in these area including raw uranium ore, fine ore, soil, processing water, wastewater, tailing mud, etc were selected to be measured. The gamma dose rate levels ranged 0.56–34.44 □Sv/h with arithmetic mean of 19.23 □Sv/h, 0.47–22.77 □Sv/h with arithmetic mean of 6.97 □Sv/h, 0.52–42.04 □Sv/h with arithmetic mean of 17.63 □Sv/h and 0.31–4.20 □Sv/h with arithmetic mean of 0.96 □Sv/h, respectively, for mining area, milling area, uranium tailings area and downstream area. Meanwhile, four soil profiles (1 m in depth) with different distance from uranium tailings were sampled and measured by gamma spectrometer to obtain the activity concentration data of ^{238}U, ^{232}Th and ^{40}K. Then, absorbed dose rates calculated based on concentrations of these radionuclides were compared with the gamma dose rate measured in situ, to understand the contributions of these radionuclides to the absorbed dose rates. The annual effective dose and its radiological hazards for the local workers were subsequently indicated.

NATURAL RADIONUCLIDE CONTENT OF NORM BY-PRODUCTS ORIGINATED FROM COAL FIRED POWER PLANT

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As a result of energy production in coal fired power plants huge amount of by-products produce. In Thermal Power Plant of Oroszlány (Hungary) different techniques have been used since 1961 to burn brown-coal with various quality can be found in the vicinity of Oroszlány. On the basis of previous studies it was found that several Hungarian coal have elevated natural radionuclide content can be enhanced as a result of burning.

In this survey coal and deposited by-product samples were examined (fly-ash, bottom-ash, fluidized bed bottom-ash, gypsum, slurry-type ash). The natural radionuclide content was determined by high resolution gamma ray spectrometry, using an ORTEC GMX40-76 HPGe detector. The data and spectra recorded by a Tennelec PCA-MR 8196 MCA.

To get information about the distribution of radionuclide content in function of the grain size distribution the bottom ash – deposited in the largest quantity – was fractionized and examined as well.

The natural radionuclide content of the coal (Ra-226 = 45.3 ± 6.3; Th-232 = 26.3 ± 5.7; K-40 = 210 ± 21 Bq/kg) is significantly lower than in case of originated ashes except in case of fluidized type. The gypsum originated from the desulphurization process has very low natural radionuclide content (Ra-226 = 22.2 ± 3.4; Th-232 = <LD; K-40= 13 ± 2.7 Bq/kg).

The average radionuclide content of the bottom ash was ~3 times higher than the coals' (Ra-226 = 144 ± 18; Th-232 = 84.3 ± 14; K-40= 260 ± 25 Bq/kg). In case of the fractionized samples it was found that the radionuclide content under 0.1 mm was 45% higher than above 1.6 mm.

ORAL PRESENTATIONS

ANALYSES OF LOCAL DOSE DISTRIBUTIONS IN THE LUNGS FOR THE DETERMINATION OF RISK APPORTIONMENT FACTORS

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The probability to induce bronchial carcinomas in a given region of the human lung by inhaled radon progeny depends on the regional dose and the corresponding regional sensitivities to lung cancer induction. While regional doses can be determined by lung dosimetry models, regional contributions to lung tumor occurrence are currently based on assumptions. In radiation protection, doses to the bronchial (BB), bronchiolar (bb) and alveolar-interstitial (AI) regions of the lung are multiplied by regional apportionment factors to account for regional sensitivities to radiation-induced lung cancer. Assuming that the tissue in each region is equally sensitive to cancer induction, ICRP has proposed equal weighting to each region, i.e. w(BB):w(bb):w(AI) = 0.33:0.33:0.33. This weighting scheme can be tested by comparing different regional dose distributions with the epidemiological evidence and with pathologically observed regional cancer distributions. Thus the objective of the present study is to compare different radon and thoron progeny exposure scenarios, which produce different regional dose distributions, comprising (i) radon progeny inhalation, (ii) thoron progeny inhalation, (iii) thoron and thoron progeny exhalation (Thorotrast patients), and (iv) radon progeny inhalation in the rat lung. Radon progeny dose distributions in the lungs are distinctly non-uniform, e.g. alveolar doses are only a few percent of bronchial doses. In contrast, the relative contribution of alveolar doses in the rat lung is significantly higher than that in the human lung. While thoron progeny dose distributions are comparable to those for radon progeny, alveolar doses for thoron and thoron progeny exhalation in Thorotrast patients are nearly an order of magnitude higher than those for the bronchial region. Since cigarette consumption is the predominant cause of lung cancer induction, deposition patterns for inhaled cigarette smoke particles were also simulated and compared with the radon progeny dose distributions. In case of concomitant exposure to radon progeny and cigarette smoke, radon progeny dose distributions may be modified by the cigarette smoke deposition patterns to account for promotion in carcinogenesis, thereby enhancing the risk in bronchial airways relative to alveolar airways. Comparison with reported cancer distributions in human and rat lungs for the different exposure scenarios suggest that apportionment factors for the bronchial and bronchiolar regions should be higher than that for the alveolar region.

ESTIMATING THE EFFECTIVE DOSE EQUIVALENT DURING TRANSPORT RADIOACTIVE MATERIAL USING THE TWO DOSIMETER APPROACH

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The two-dosimeter approach was used in this work to calculate the effective dose equivalent (EDE) that the drivers may be exposed to during transporting radioactive materials. An external radiation source (Cs-137) was loaded into the back side of a vehicle, and a water phantom was used in the cabinet of the vehicle. The phantom is covered by a 3x3 matrix of TLD detectors on the front side of the body for the first irradiated experiment, and another matrix was placed on its backside for the next irradiation. The scenario was simulated using MCNP5 Monte Carlo code to estimate the conversion factors for the different angular distribution of the Cs-137 source at 175 cm from the back side of the body. The results as a function of the angle were tabulated for the entrance dose which corresponds to the detector matrix in the back of the phantom and for the exit dose that corresponds to the detector cells at the front of the matrix. The absorbed fractions that represent (entrance-exit)/entrance against the angle were calculated from which the absorption of the beam by the phantom was obtained.

NON-DESTRUCTIVE DETERMINATION OF URANIUM, THORIUM AND 40K IN TOBACCO AND THEIR IMPLICAITON ON RADIATION DOSE LEVELS TO THE HUMAN BODY

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The naturally occurring radionuclides of uranium and thorium and their daughter products are still a major source of anthropogenic radiation to tobacco smokers. Often overlooked is the presence of ^{40}K in tobacco and its implication to radiation dose accumulation in the human body. We have determined these three radiation sources in five typical USA cigarettes using neutron activation analysis (NAA). We used the following NAA reactions $^{238}U(n, \gamma)^{239}U$, $^{232}Th(n, \gamma)^{233}Th$ and $^{41}K(n,\gamma)^{42}K$ to determine uranium, thorium and ^{40}K reseptively, The activity of ^{238}U can easily be determined by epithermal neutron activation analysis of the $^{238}U(n,\gamma)^{239}U$ reaction. The use of epithermal neutrons, as opposed to typical thermal neutron activation analysis, allows for the better counting statistics at low uranium concentrations; this is due to both the large epithermal absorption cross-section of ^{238}U and the low epithermal absorption cross-sections of ^{37}Cl and ^{23}Na. The $^{23}Na(n,\gamma)^{24}Na$ and the $^{37}Cl(n,\gamma)^{38}Cl$ reactions typically increase the Compton continuum of irradiated biological samples, increasing the background signal and reducing our ability to detect nuclides at low-level concentrations. Using isotopic ratios, the activity due to ^{40}K was found by the determined concentrations of ^{41}K (also by epithermal neutrons) in the bulk material. Each gram of total potassium yields 30 Bq of ^{40}K. A preliminary radiation dose assessment was made for a typical tobacco smoker using one package of cigarettes a day.

DOSE CONVERSION COEFFICIENTS FOR EXTERNAL RADIATION PROTECTION USING TAIWANESE REFERENCE MEN

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Reference man has been widely used for external and internal dose evaluation of radiation protection. The parameters of the mathematical model of organs suggested by the International Commission of Radiological Protection (ICRP) are adopted from the average data of Caucasians. However, the organ masses of Asians are significantly different from the data of Caucasians, leading to potentially dosimetric errors. In this study, a total of 40 volunteers whose heights and weights corresponded to the statistical average of Taiwanese adults were recruited. Magnetic resonance imaging was performed and T2-weighted images were acquired for head, neck, thorax, abdomen, and pelvis. The Taiwanese reference man and female were constructed according to the measured organ mass. The dose conversion coefficients for anterior-posterior, right lateral, and left lateral irradiation were simulated with photon energy ranging from 40 keV to 10 MeV. Most of the organ masses were within 50% difference compared to the results of the ICRP reference man. The maximum difference of the dose conversion coefficients between the Taiwanese reference man and the ICRP-74 reference man reached 20%. The maximum difference for the Taiwanese reference female was 36%. The geometric parameters of the reference phantoms can cause significant impacts on the dose conversion coefficients for external exposure of radiation. The constructed Taiwanese reference man and female could be used in radiation protection to increase the accuracy of external dose evaluation.

ASSESSMENT OF RADIOLOGICAL HAZARD ASSOCIATED WITH A CALIBRATION FACILITY FOR FIELD RADIOMETRIC INSTRUMENTS

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A calibration facility comprising of background, potassium, uranium and thorium transportable (1m x 1m x 0.3m) radioactive pads was recently established at the Centre for Energy Research and Training (CERT). The facility is to serve calibrations needs of scientists and researchers in Nigeria and perhaps part of sub-Saharan Africa. This paper presents assessment of radiological hazard associated with the facility. Results of Raeq, Hex, Hin and Iγ for the pads range from 175.94 to 6602.11 Bq/kg, 0.16 to 74.03, 0.23 to 86.22 and 0.21 to 95.16 respectively. The Hex, Hin and Iγ indexes for thorium pad appeared to be high much higher than unity indicative of potential hazard, thus, necessitate optimum caution when using it. On the contrary, the indexes for the other three pads were below the unity safety limit, as a result pose no radiation risk neither on prospective users nor the immediate environment.

LUNG CANCER IN GERMAN URANIUM MINERS – RADON-ASSOCIATED RISK AT LOW EXPOSURE RATE

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Background: The present analyses of the German Wismut uranium miners cohort study (n=58,982) focus on the subgroup of miners first employed in 1960 or later. This subgroup of miners is characterized by low levels of measured radon exposure (average cumulated exposure 17 WLM, max=334) protracted over a long period (mean duration of exposure 10 years). Also data on smoking is available for more than half of this subgroup.

Methods: The sub-cohort includes 26,727 men who had been employed between 1960 and 1989 for at least 180 days at the Wismut company with epidemiological follow-up to the end of 2008. Annual exposure to radon progeny in Working Level Months (WLM) was retrospectively assessed by means of a comprehensive job-exposure matrix for each work place, job type and facility based on extensive ambient measurements. The Excess Relative Risk (ERR) per unit of cumulative exposure to radon in WLM and 95% confidence intervals (CI) were calculated using a linear Poisson regression model.

Results: There were 843,350 person-years at risk and 3,812 deaths including 333 from lung cancer (n). A statistically significant relationship between death from lung cancer and cumulative radon exposure was found (ERR/WLM=0.013, 95% CI: 0.006; 0.020). Restriction of radon exposure to less than 100 or 60 WLM resulted in slightly higher risk estimates: n=305, ERR/WLM=0.017; (95% CI: 0.007; 0.027) and n=260, 0.018 (95% CI: 0.004; 0.032), respectively. Information on smoking status was available for 58% of the subgroup. The smoking related relative risk of lung cancer among light, moderate/heavy and unknown smokers compared to non-smokers was 3.2 (95% CI: 0.4;6.0); 8.9 (95% CI: 2.5;15.2) and 5.1 (95% CI: 1.5;8.8). Adjustment of the radon-related lung cancer risk for smoking status, cumulative silica dust exposure or cumulative external gamma exposure resulted in no major changes of the estimated risks. No statistically significant improvement of the model fits were achieved when exponential time or age risk effect modifiers were included in the models.

Conclusion: The present findings are consistent with previous results from a combined analysis of French and Czech cohorts on the risk of lung cancer due to low dose radon in miners (i.e., ERR/WLM=0.027; 95% CI: 0.017;0.043; mean cumulative radon exposure 47 WLM) or German uranium millers who never worked underground with very low radon exposures similar to those in homes (ERR/WLM=0.034; 95% CI: -0.0001; 0.068; mean=8 WLM).

EPIDEMIOLOGICAL STUDIES IN HIGH BACKGROUND RADIATION AREAS

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Most epidemiological studies on low-dose rate radiation exposure have relatively low cumulative doses, making it difficult to evaluate radiation-related risk. It should be noted that such evaluation requires a long-term follow-up of a large population. Note also that there are many risk factors, such as smoking, are much more strongly associated with cancer risk when compared with radiation exposure. As a result, even a weak association of radiation doses with such a factor can confound the relationship between radiation exposure and cancer risk. Important epidemiological studies for evaluating the cancer risk associated with relatively low-dose-rate exposure include those on residents in high man-made background radiation (HMBR) areas, including Chernoby and the Techa River. Other important studies are those conducted in high natural background radiation (HNBR) areas. This paper will describe epidemiological studies on the residents in the HNBR areas in Karunagappally in Kerala State, India, and Yangjiang in Guangdong Province, China.

POSTER PRESENTATIONS

RISK OF LUNG CANCER AFTER INHALED "HOT PARTICLE" IN BULGARIAN POPULATION

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Exposure of the lung to beta and alpha irradiation from discrete highly radioactive particles (called "hot particles") represents a difficult problem for assessment the radiation risk and radiological protection. A new report from independent scientists in Japan found a much greater release of "hot particles" from the Fukushima power plant than originally estimated. These include radioactive isotopes of cesium, strontium, uranium, plutonium, cobalt-60 and many others. The average person in Tokyo is thought to have inhaled 10 "hot particles" per day throughout the month of April 2011. The inhabitants of Fukushima were estimated to have inhaled 30-40 times more than that—or up to 400 hot particles per day every day that month. in Seattle, WA in the Northwestern U.S., it is estimated that the average person absorbed five "hot particles" per day during the month of April 2011, or 10 "hot particles" per day if they are athletes who are working out. These invisible atomic particles become lodged in your lungs, intestines, bone or muscle.

After the Chernobyl NPP accident we have provided the epidemiological study for determining the rate of lung cancer among Bulgarian population in the latest period after accident. The rate of lung cancer among Bulgarian population was determining for the period 1992 - 2003. Our measurements have shown activities of identified hot particles to range from several tens to several hundreds Bq per particle. The epidemiological results among Bulgarian populations show that the increasing of lung cancer incidents varying in the range of spontaneous frequency. A new report from independent scientists in Japan found a much greater release of "hot particles" from the Fukushima power plant than originally estimated. These include radioactive isotopes of cesium, strontium, uranium, plutonium, cobalt-60 and many others. The average person in Tokyo is thought to have inhaled 10 "hot particles" per day throughout the month of April 2011. The inhabitants of Fukushima were estimated to have inhaled 30-40 times more than that—or up to 400 hot particles per day every day that month.

In Seattle, WA in the Northwestern U.S., it is estimated that the average person absorbed five "hot particles" per day during the month of April 2011, or 10 "hot particles" per day if they are athletes who are working out. These invisible atomic particles become lodged in your lungs, intestines, bone or muscle.

The government recommends that the maximum permissible lung particle burden for members of the public be 0.2 hot particles, and the average lung burden for members of the public be 0.07 hot particles, a factor of 3 less than the maximum.

Let's say that the official numbers were five "hot particles" per day (10 if one is physically active outdoors) for everyone on the west coast for the month of April. Now let us be very conservative and say that this has dropped from the initially high post-explosion levels at Fukushima down now to one a day.At one a day that would still be 30 of these death particles a month. So perhaps the average person has already absorbed in these three months approximately 200 radioactive particles into their lungs and other tissues. When you think that if even one of these 200 is plutonium, we have to think in terms of millions of eventual cancer deaths! The fuel rods at all six reactors at the stricken Fukushima Daiichi complex contain plutonium. Only six percent of the fuel rods at the plant's unit 3 were a mixture of plutonium-239 and uranium-235 when first put into operation.The fuel in other reactors is only uranium, but plutonium is created during the fission process. This means the fuel in all of the stricken reactors and spent fuel pools contain plutonium. Plutonium is super nasty stuff, especially damaging to lungs and kidneys. Inhaling or ingesting only one radioactive particle of plutonium can cause cancer…….

POOLED BAYESIAN META-ANALYSIS OF TWO POLISH STUDIES ON RADIATION INDUCED CANCERS

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The robust Bayesian regression method was applied to perform meta-analysis of two independent studies on low ionizing radiation doses of influence on the impact on the occurrence of fatal cancers. The re-analyzed data comes from occupational exposure analysis of nuclear workers in Swierk (Poland) and from ecological study of cancer risk from natural background radiation in Poland. Such two different types of data were analyzed and three popular models were tested: constant, linear and quadratic dose-response dependencies. The Bayesian model selection algorithm for all models was used. The Bayesian statistics goes to show that the popular linear no-threshold (LNT) assumption is not valid for presented cancer risk in the range of low doses of ionizing radiation.

DOSIMETRIC EVALUATION IN INDUSTRIAL RADIOGRAPHY OPERATIONS

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Industrial Radiography is the most used technique to control structures and identify their state of wear. It is used in all branches of industry. The most commonly radio-elements used in radiography testing are Iridium -192, Selenium -75 and cobalt-60. These give a very hard radiation, making them particulary suitable for examining very thick objects.

The selection of which radio-element to use for gammagraphy should normally be determined in accordance with the type and physical size of the object to be radiographed.

For operating organizations that have several gamma sources, the lowest activity source consistent with obtaining the desired radiograph should be used. If there is a choice between using, for example, a 4,4 TBq (120Ci) inducing a dose rate of about 0,54 Sv/h at 1meter.

Industrial radiography operators are considered the professionals most exposed to ionizing radiation. Working conditions on an industrial site in the workshop or on site are often difficult (working alone, outside, at night, in height, in hostile environments) and the radiation protection principles are not always easy to apply. These difficulties, and the care about the safety in industrial radiography, give rise to elaborate a dosimetric study evaluating these radiological practices and compare the results with the international practice.

This study was conducted in collaboration with various entities working in synergy : the institutional actors (Ibn Tofail University , Kenitra, Maâmora Nuclear Studies Centre) , businesses (industrial maintenance, industrial radiography , Home Inspection: Welding Institute - Morocco , TEST -NDT , Delatre Levivier –Morocco, CTTI, Public Laboratory Testing and Research) and the Laboratory of Dosimetry and Calibration CNESTEN.

Indusrial radiography work poses a risk. However experience shows that incidents or accidents involving industrial radiography sources have sometimes resulted in high doses to workers, causing severe health consequences such as radiation burns and, in a few cases, death.

Membres of the public have also suffered radiation overexposures when radioactive sources used for industrial radiography were not properly controlled or regulated.

In view the high activity used, industrial radiography present a risk to workers that the results of the study will prevent and limit, so it will be a tool focusing on the need for an optimized organization to reduce individual and collective dosimetry.

MEASUREMENT OF THE ENVIRONMENTAL GAMMA DOSE SURROUNDINGS NUCLEAR PLANTS OF ARGENTINA

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The Nuclear Regulatory Authority (ARN) is the institution of the Argentine State dedicated to the control and regulation of nuclear activities. It is an autonomous entity within the jurisdiction of the General Secretariat of the Presidency of the Nation, created in 1997 by the National Nuclear Activity Act (N° 24 804).

The ARN carries out the environmental radiation monitoring in the surroundings of the several radioactive and nuclear facilities in our country. This monitoring concern the measurement of absorbed dose rates in air or activity concentrations resulting from a defined source or practice. These measurements are afterwards compared with the values set out in national regulations and international recommendations, and with the values obtained from the environmental models used for the ARN radiation protection control of public.

The environmental gamma dose in air determination is performed using thermoluminescent detectors (TLD), this monitoring is done in the surroundings of the two existing nuclear power plants in our country (they are named Nuclear Power Plant "A" and "B") and into two nuclear sites (a nuclear site is a place with investigation reactors, irradiation facilities, etc., they are named nuclear site “C” and “D”) for monitoring the facilities.

The average levels of environmental dose rate in air measured in surroundings of the nuclear power plants and into the nuclear sites, are consistent with the average value of 58 nGy/hr reported by UNSCEAR for places not influenced by nuclear facilities.

The objective of this work is present the results of the monitoring plan developed by the ARN for the environmental gamma dose in the surroundings of the Nuclear Power Plants and into Nuclear Sites in Argentina, carried out during the last five years, and verifying the consistency with the results of calculation models to ensure that it is operating in compliance with established regulations.

STUDY OF RADON ACTIVITY, EXHALATION RATE AND RADIATION DOSES IN COAL AND FLY ASH SAMPLES COLLECTED FROM NTPC BADARPUR, DELHI, INDIA

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Coal is a technologically important material used for power generation. The increasing demand for electricity generation for industrial development and human living standards worldwide is met by combustion of fossil fuels. Since coal contains ^{226}Ra, ^{232}Th and ^{40}K radionuclide, so it is important to measure the radiation risk to population. Coal and flyash samples were collected from NTPC (National Thermal Power Corporation) situated at Badarpur, Delhi, India.

Fly ash is used in the production of bricks, sheets, cement and also in land filling etc. As the elements in fly ash are concentrated due to combustion of coal in thermal power plants, the knowledge of radionuclides in fly ash plays an important role in health physics.

Radon activities and radon exhalation rates have been measured in coal and fly ash samples collected from NTPC (National Thermal Power Corporation) Badarpur, Delhi, India using "Seald Can Technique", which employs LR-115 type II solid state nuclear tracks detectors. In coal samples radon activity has been found to vary from 505.4 ± 39.0 to 932.1 ± 52.9 Bqm-3 with an average value of 687.2 ± 45.2 Bqm-3. Surface exhalation rate has been found to vary from 182 ± 14.0 to 336 ± 19.1 $mBqm^{-2}h^{-1}$ with an average value of 248 ± 16.3 $mBqm^{-2}h^{-1}$, whereas mass exhalation rate is found to be vary from 7.0 ± 0.54 to 12.9 ± 0.73 mBq $kg^{-1}h^{-1}$ with an average value of 9.5 ± 0.62 mBq $kg^{-1}h^{-1}$. Calculated values of indoor inhalation exposure (radon) effective dose are vary from 13.3 ± 1.02 to 24.5 ± 1.39 μ Sv y^{-1} with an average value of 18.1 ± 1.18 μ Sv y^{-1}. In flys ash samples radon activity has been found to vary from 400.0 ± 34.7 to 483.9 ± 38.1 Bqm^{-3} with an average value of 447.1 ± 36.6 Bqm^{-3}. Surface exhalation rate has been found to vary from 144 ± 12.5 to 174 ± 13.7 m Bq $m^{-2}h^{-1}$ with an average value of 161 ± 13.2 m Bq $m^{-2}h^{-1}$, whereas mass exhalation rate is found to be vary from 5.5 ± 0.5 to 6.7 ± 0.5 mBq $kg^{-1}h^{-1}$ with an average value of 6.2 ± 0.5 $mBqkg^{-1}h^{-1}$.

ORAL PRESENTATIONS

THYMIC LYMPHOMA SUPPRESSIVE DNA DAMAGE REPAIR PATHWAY RELATED GENE EXPRESSIONS IN THE THYMUS OF LOW-DOSE-RATE IRRADIATED MICE

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We investigated the expression of DNA repair and damage pathway related genes in the thymus of AKR/J and ICR mice after low-dose-rate (Cs-137, 0.7 mGy/h, a cumulative dose: 1.7 Gy) irradiation. Thymuses were collected at 100th day irradiation and analyzed using whole-genome microarray, quantitative reverse transcription polymerase chain, and western blot. The thymus weight was decreased and survival rate was increased in low-dose-rate irradiated AKR/J mice. We analyzed expression of DNA repair and damage-related genes in low-dose-rate irradiated ICR and AKR/J using microarray, qPCR and western blot. The expressions of tumor suppressor, RND-3 (Rnd3 or RhoE) and PLXNC1 (Plexin C1), were up-regulated, whereas the expression of CYP11A1 (p450scc), a protein contributes to tumor immune escape, was down-regulated in LDR irradiated AKR/J mice, but not ICR mice. These results suggest that low-dose-rate γ-radiation suppressed early stage of carcinogenesis and removed cancer cells from body by stimulated apoptosis and immune mechanisms.

ANALYSIS OF SERIAL CHANGE OF OXIDATIVE STRESS-RELATED MARKERS IN THE PATIENTS WITH RECURRENT THYROID CANCER UNDERGOING 131-I RADIONUCLIDE THERAPY.

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When a nuclear power plant disaster occurs, radiation exposure to human organs by radioactive materials such as 131-I can induce a variety of biological effects including carcinogenesis. In the current study, as a basis to speculate the radiobiological effects of 131-I on human organs, we evaluated the serial change of the oxidative stress-related marker in the patients undergoing 131-I radionuclide therapy (RNT).The subjects were the patients presenting with recurrent thyroid cancer who underwent 131-I RNT following surgery. To avoid the direct and indirect influences from existing cancer and pay attention to the production of oxidative stress due to radiation, the patients after total/partial resection of recurrent tumor, dissection of lymph node metastases, and resection of remnant hemi-thyroid if necessary were selected for the study. Urine samples were used for the measurement of urinary 8-OHdG, a representative oxidative stress-related marker. They were collected before and during treatment, and a month later. The value of urinary 8-OHdG was adjusted to urinary creatinine.

As a result, the serially changing pattern of urinary 8-OHdG in the patients who were delivered 131-I of 3.70 GBq administration (group A) differed from that for those delivered 131-I of 5.55 GBq (group B). In group A, urinary 8-OHdG rose up immediately after the administration of 131-I, and reached its peak value. The significant difference was found between the values of control and those for the peak ($p=0.0277$). In group B, two of three cases revealed the high control value and the inconstant change during treatment. Further, one month later, they still had a higher value of 8-OHdG than that for control. In group B, the existence of gross tumor after partial resection appeared to result in the high control value. It was suggested that the biological effects from both residual tumor and 131-I influenced on the results with a complexity in the patients of group B. Therefore, it appeared difficult for them to observe pure influence from administrated 131-I. On the other hand, in the patients of group A, no gross tumor existed. In this case, serial change of urinary 8-OHdG during treatment was considered available to assess the radiobiological effects from 131-I administration.

CHANGES IN GLOBAL GENOME METHYLATION IN ZEBRAFISH EMBRYOS UPON ALPHA IRRADIATION

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Over the past twenty years, non-targeted effects induced by ionizing radiation such as the radiation-induced bystander effect and radiation-induced genomic instability have been extensively studied. In particular, radiation-induced genomic instability has been considered an important cause for carcinogenesis. However, the mechanisms underlying such non-targeted effects are still not fully understood. Accumulating evidence has demonstrated that radiation exposures can lead to epigenetic alterations, which play an important role in genomic instability that can affect the next generation. In the present work, epigenetic alterations in terms of global changes in DNA methylation induced by alpha particles were studied using zebrafish (Danio rerio) embryos as the in vivo animal model. In the present study, genomic DNA was extracted from the zebrafish embryos at 24 hpf by using the phenol-chloroform DNA extraction method. The 5-mC DNA ELISA Kit (Zymo Research Corporation) was first used to detect global DNA methylation. We further validated results by high-performance liquid chromatography (HPLC), a gold standard in the field to quantify genomic DNA methylation. We made reference to our previous study which, by using the amount of apoptotic signals as the biological endpoint, demonstrated a hormetic effect in zebrafish embryos exposed to alpha-particle irradiation with a dose of ~1.1 mGy. Our preliminary data showed that the levels of DNA methylation remain unchanged when exposed zebrafish embryos to alpha particles with doses ranging from ~1.1 to 4.4 mGy. Further studies with larger sample size and HPLC analyses were also performed to examine epigenetic alterations under different doses of alpha-particle irradiation. This study suggested that our in vivo zebrafish animal model could be used to examine DNA methylation alternations which could provide insights into the key epigenetic modification in ionizing radiation biology.

MULTIPLE STRESSOR EFFECTS OF DEPLETED URANIUM AND IONIZING RADIATION ON ZEBRAFISH EMBRYOS

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In realistic situations, living organisms are exposed to a mixture of environmental stressors, and the resultant effects due to such exposures are referred to as multiple stressor effects. Multiple stressor effects might not be simply the sum of effects from individual stressors. The present paper reports our studies on the multiple stressor effects of uranium and ionizing radiation on embryos of the zebrafish, Danio rerio.

Adult zebrafish were reared in glass tanks with water kept at 28°C, and with a 14/10 hour light-dark cycle. When the 14-h photoperiod started, zebrafish embryos produced by photo-induced spawning were collected and transferred to a 28°C incubator. The ionizing radiation employed in this study included the high-linear-energy transfer (LET) alpha particles (external alpha irradiation using ^{241}Am sources) and the low-LET photons (external gamma irradiation using ^{137}Cs sources). For each type of radiation, the experimental strategy involved four sets of experiments, namely,

100 μg/L high concentration of uranium + high dose of ionizing (alpha or gamma) radiation;
10 μg/L low concentration of uranium + low dose of ionizing (alpha or gamma) radiation;
100 μg/L high concentration of uranium + low dose of ionizing (alpha or gamma) radiation;
10 μg/L low concentration of uranium + high dose of ionizing (alpha or gamma) radiation.

Each experiment consisted of four groups, namely, (A) the control group (no exposures to uranium or ionizing radiation), (B) the uranium exposure group, (C) the ionizing radiation exposure group, and (D) the (uranium + ionizing radiation) exposure group. The combined toxic effects of (uranium + ionizing radiation) exposure were determined through comparisons of the biological endpoints in group (D) to those in groups (A), (B) and (C). The biological endpoints for the zebrafish embryos chosen for the present study were morphologic abnormalities and the number of apoptotic signals at 24 hpf. The results will be presented and discussed. The effects of (uranium + alpha radiation) and (uranium + gamma radiation) will also be compared.

The conclusion from the present study is particularly important in areas close to nuclear power plants, since anthropogenic uranium is expected to be contributed from nuclear fuel cycle activities while □- or □-emitting radionuclides are expected to be released in routine as well as accidental fallouts.

OXIDATIVE STRESS INDUCED BY IONIZING AND NON-IONIZING RADIATION: DIFFERENCES AND SIMILARITIES

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Overproduction of reactive oxygen species as a first step to oxidative stress is involved in many pathologies and diseases including cancer, neurodegeneration, inflammation, aging and others. Thus oxidative damage of DNA results in alters of transcription rate, replication errors and genomic instability. And in different cancer tissues an increased level of oxidative damage of DNA was reported.

In this study we aim to compare oxidative effects of low intensity ionizing radiation and non-ionizing/radiofrequency radiation (RFR). We analyze the results of our own and published research conducted in the Chornobyl zone and effects of RFR from modern mobile communication systems.

A significant, about fourfold, increase of superoxide radical levels in hepatocytes and kidney cells of rats of the Chornobyl group compared to the Kyiv group and the before-the-accident control was detected us 1-2 years after the accident. A significant increase of hydroxyl radical levels in hepatocytes of the Chornobyl rats was detected during this period as well. (The Chornobyl group of white mature mongrel rats, 3 months old have been delivered into the experimental base at the Chornobyl Exclusion Zone in Oct 1986. The external gamma radiation background was about 100 – 200 μR/h during Oct 1986 - Oct 1987, and 75 - 100 μR/h during Oct 1987 - Oct 1988.) Later on in a field study during June 2000 and June 2002 an international team of researchers detected a significantly reduced level of antioxidants (retinol, carotenoids, α-tocopherol) in blood, liver and eggs of barn swallows of the Chornobyl area compared with data from an uncontaminated control area of Ukraine (Moller et al., 2005).

For RFR risk assessment we used so small intensity of RFR as 0.25 $\mu W/cm^2$ (three orders of magnitude lower than ICNIRP safety limits) and nevertheless detected a significant effect on the model of Japanese quail embryos. The data obtained indicate that exposure of quail embryos to extremely low intensity RFR of GSM 900 MHz leads to a significant overproduction of superoxide and nitrogen oxide in embryo cells and results in significant features of oxidative stress, including oxidative damage of DNA, comparable to the effects of low intensity ionizing radiation.

The differences in primary mechanisms of oxidative stresses caused by ionizing and non-ionizing radiations are discussed.

EFFECTS OF A C-MPL RECEPTOR AGONIST ON MICE EXPOSED TO LETHAL IONIZING RADIATION

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In a high-dose radiation-exposed individual, top priority is given to treatments intended to reconstitute and restore hematopoiesis. In scenarios with many patients, such as radiation accidents, drug therapy is the most suitable initial treatment, and therefore, a stable supply and regular stockpile of approved pharmaceutical drugs is desired. Our previous study described an optimum protocol based on a combination of currently approved pharmaceutical drugs that increased the survival rates of mice exposed to lethal irradiation. In that study, we achieved 100% survival of the irradiated mice with the addition of a c-mpl receptor agonist. In the current study, we examined the effects of a c-mpl receptor agonist on mice exposed to lethal ionizing radiation. The c-mpl receptor agonist was administered at a dosage of 50 μg/kg of body weight/day to 8-week-old female C57BL/6JJcl mice for 1, 3, or 5 days immediately following exposure to a lethal 7-Gy dose of 137Cs γ-rays. The animals' health was analyzed via morphological evaluations of the small intestine and various parameters such as the numbers of peripheral blood cells, bone marrow cells, and hematopoietic progenitor cells along with cell surface antigen expression. By day 30, all untreated irradiated control mice died, whereas c-mpl receptor agonist administration for 3 or 5 consecutive days after irradiation led to a 100% survival rate among the irradiated mice. At this time, there were no significant differences in the numbers of peripheral blood cells, bone marrow cells, and hematopoietic progenitor cells, and myelosuppression had not recovered. However, significant recovery was observed with respect to bone marrow cell surface antigen expression and the small intestine tissue specimens until day 20. The present findings demonstrate that the c-mpl receptor agonist might be a new medical countermeasure for accidental radiation exposure victims.

RADIOPROTECTIVE ACTION OF OMEGA 3 FATTY ACID ON LEUKOCYTE CELL CULTURES

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Omega-3 fatty acids are long-chain polyunsaturated fatty acids and consist mainly of EPA (Eicosapentaenoic acid) and DHA (Docosahexaenoic acid). In several research the omega 3 fatty acid as evaluated as anticancerous agent and can be use as a radioprotectant. It shows the effective reduction in oxidative stress. Radiation causes the damage in DNA and also enhances the oxidative stress in the cell.

When cell cultures are exposed to radiation the analysis shows increase in oxidative stress such as Superoxide dismutase, Catalase, glutathione peroxidase, lipid peroxidase etc. The cell cultures supplemented with omega 3 fatty and exposed to radiation are analysed it shows decreased oxidative stress. Omega 3 fatty acid work as radioprotectant when the radiation induced into the cell the physiological changes in cell is stablised by the omega 3 fatty acid.

There is a significant positive association between the effect of omega 3 fatty acid series and poor blood plasma antioxidant status. Omega 3 fatty acids are considered as potential important antioxidants (Hodge et al).

Polyunsaturation helps in the scavenging of free radicals by reacting with free radical to make inactive free radicals by forming stabilized free radical adducts. with the respective knowledge by research papers and results we are further evaluating the properties of omega 3 fatty acid as radioprotectant or radioprotective action of omega 3 fatty acids on the cell culture and cell lines. Further results and discussion will discuss later.

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POSTER PRESENTATIONS

EFFECT OF RADON INHALATION ON BLOOD CELLS IN RATS

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The major source of human exposure to natural radiation arises from the inhalation of radon (^{222}Rn) gas. Exposure to high concentrations of radon ^{222}Rn and its daughters for long period leads to pathological effects like lung cancer, leukaemia, skin cancer and kidney diseases. The present study was designed to evaluate the effects Rn inhalation on some biochemical properties of blood including red and white blood cells counts, haemoglobin level, haematocrite value, mean red blood cell volume, mean red blood cell haemoglobin, and mean red blood cell haemoglobin concentration. In addition, liver enzymes activities e.g., alanine aminotransferease (ALT), aspartate aminotransferase (AST) and glucose level were assessed in serum. Finally sections sections from lung, brain, liver, kidney and bone were subjected to histopathological examination. To carry out the required biological studies, adult male albino rats were exposed to different concentrations of Rn and its daughters for for 4 hours a day and 3 days a week for a period of 3, 5 or 7 weeks inside radon chamber using uranium ore stone to simulate miners environmental conditions. The Rn concentrations are measured using CR-39 solid state nuclear track detector; it is a standard tool for measuring Rn concentration. CR-39 etched in 6.25N – NaOH for 6 hours at 70□ C. The accumulated Rn doses received by animals over 3, 5 and 7 weeks were found to be 2.45, 4.09 and 5.72 WLM respectively (based on exposure hours per week). The results indicated decreased haemoglobin, RBCs count, hematocrite value and mean cell volume with increasing Rn doses. Platelet count decreased while white blood cell count increased after exposure to Rn. AST decreased while ALT increased in serum. Blood glucose increased. Exposure to radon resulted in widespread damage in different organs of the body.

EFECTS OF IONIZING RADIATION ON RETINOIC ACID-INDUCIBLE GENE-I-LIKE RECEPTORS

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[Object] The immune system is composed of innate and adaptive immunity. Antigen presenting cells (APCs), such as macrophages and dendritic cells, serve as a link between innate and adaptive immunity. Furthermore, APCs express pattern recognition receptors (PRRs) which recognize pathogen-associated molecular patterns. Retinoic acid-inducible gene-I (RIG-I)-like receptors [RLRs; RIG-I and melanoma differentiation-associated gene 5 (MDA5)] are a type of PRRs and sense virus-derived RNA or a synthetic analog of dsRNA polyinosinic-polycytidylic acid [poly(I:C)]. Although macrophages are resistant to ionizing radiation, it remains unclear whether radiation affects RLR expression in the macrophages. Therefore, the effects of ionizing radiation on the RLR expression in macrophages and the response against poly(I:C) were herein investigated.

[Methods] For preparation of human macrophage-like cells, the human acute monocytic leukemia THP1 cells were treated with phorbol 12-myristate 13-acetate and then differentiated into macrophage-like cells. To stimulate RLRs, poly(I:C)/LyoVecTM (InvivoGen), which is a complex between poly(I:C) and the transfection reagent LyoVecTM, was used on THP1-derived macrophage-like cells. X-irradiation was performed with an X-ray generator at a dose rate of 102.0–104.0 cGy/min. The expression of RLRs was analyzed by reverse transcription polymerase chain reaction (RT-PCR) or western blotting. The interferon (IFN)-β expression and tumor necrosis factor (TNF)-α concentration present in culture supernatants were analyzed by RT-PCR and enzyme-linked immunosorbent assay (ELISA), respectively.

[Results] The effects of ionizing radiation on RLR expression were first investigated. Both non-irradiated and X-irradiated (1–10 Gy) macrophage-like cells expressed RIG-I and MDA-5, with no significant difference in expression levels. Next the response of macrophage-like cells to poly(I:C)/LyoVecTM (500 ng/ml) was examined. Although the expression of IFN-β was not observed in non-stimulated macrophage-like cells, the poly(I:C)/LyoVecTM-stimulated macrophage-like cells expressed IFN-β. In X-irradiated macrophage-like cells, IFN-β expression after poly(I:C)/LyoVecTM stimulation was comparable with that of non-irradiated cells. Similar to the IFN-β expression, no significant difference in concentration of TNF-α were observed after poly(I:C)/LyoVecTM stimulation in non-irradiated and irradiated cells. These results suggest that ionizing radiation did not affect RLR expression or the response against poly(I:C) in THP1-derived macrophages.

INJURY OF THE BLOOD-TESTIS BARRIER AFTER LOW-DOSE-RATE CHRONIC RADIATION EXPOSURE IN MICE

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The blood-testis barrier plays an important role in the male reproductive system. Many environmental stimuli can increase the permeability of the blood-testis barrier and result in male infertility. We investigated the effects of low-dose-rate chronic radiation on male mice by measuring levels of tight-junction-associated proteins (ZO-1 and occludin-1) and Niemman-pick disease type 2 protein (NPC-2) as well as anti-sperm antibody (AsAb) in serum. We exposed BALB/c (5 per group) mice to low-dose-rate radiation (3.49 mGy/h) for total exposure of 0.02 Gy (for 6 h), 0.2 Gy (for 2 days), and 2 Gy (for 21 days). Based on histological examination, the diameter and epithelial depth of seminiferous tubules were significantly decreased in the mice irradiated with 2 Gy radiation. Compared with the sham group, the ZO-1 and occludin-1 levels significantly decreased after 2 Gy radiation exposure. The expression of the NPC-2 protein significantly decreased, accompanied with increased serum AsAb levels in radiation-exposed mice. These results suggest potential blood-testis barrier injury and immune infertility in male mice exposed to a certain intensity of low-dose-rate chronic radiation.

CYTOGENETIC DOSIMETRY IN PERIPHERAL BLOOD CELLS OF RECURRENT THYROID CANCER PATIENTS, INFLUENCED BY DEFICIENCY OF THYROID HORMONE REPLACEMENT

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Cytogenetic dosimetry is recognized as a valuable dose assessment method which fills a gap in dosimetric technology in cases where there is reason to believe that persons not wearing dosimeters have been exposed to ionizing radiation. Especially, cytokinesis-block micronuclei (CBMN) assay is a convenient and easy method using peripheral blood cells. However, for micronuclei frequency induced by ionizing radiation, dose response relationship in cancer patients has not been settled, because there is a complicated situation in the cancer patient's body. Our previous data suggested that bioactive factors, such as cytokines, have influenced indirectly to metabolism of oxidative stress. The purpose of this study was to clarify the serial change of ionizing radiation response of micronuclei in recurrent thyroid cancer patients, who underwent thyroid hormone replacement therapy and had a pause of administration to prepare for 131-I treatment, and then to investigate the influence of thyroid hormone deficiency on human cells .

This study was approved by the Committee of Medical Ethics of Hirosaki University Graduate School of Medicine (Hirosaki, Japan). To clarify the difference of dose-response curve of the CBMN assay before and after a pause period of administrating thyroid hormone for 2 weeks prior to 131-I treatment, 12 patients presenting with recurrent thyroid cancer, given thyroid hormone replacement therapy following thyroidectomy, were studied. All donors explicitly agreed to participate in this study. The peripheral blood monuclear cells, collected before and after the pause period, were exposed to 0.5 – 3.0 Gy X-ray irradiation (150 kVp, 20 mA, 0.5-mm aluminum and 0.3-mm copper filters) using an X-ray generator (MBR-1520R-3, Hitachi Medical Co. Ltd., Tokyo, Japan). The obtained data of CBMN assay was analyzed according to the criteria of the IAEA.

Higher micronuclei frequency was observed to thyroid cancer patients in comparison to healthy volunteer, and various detection rates of micronuclei was shown. The 67% patients controlled thyroid function by related hormone was shown the micronuclei frequency of dose dependent. On the other hand, about 42% patients was shown in un-controlled condition. Furthermore, un-controlled condition was induced saturated state of micronuclei frequency (1.0 - 3.0 Gy). These results suggested that the micronuclei frequency for cytogenetic dosimeter in thyroid cancer patients is characteristic and depends on the presence of thyroid hormone.

STUDY OF OH RADICALS SCAVENGING INITIATED BY X-RAY RADIATION IN HUMAN PLASMA.

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Approximately 60- 70% of the cellular DNA damage produced by X-ray irradiation is caused by hydroxyl (OH) radicals formed from the radiolysis of water. These radicals play a major role in radiation-induced biological damage. Human plasma is a source of OH radicals caused by X-ray irradiation, and, at the same time, has a radical-scavenging function. It is possible that the radical -scavenging function causes a radiation protective effect in humans. We studied the amount of OH radical generated via X-ray irradiation in human plasma by using electron spin resonance (ESR) and found that some human plasma had OH radical scavenging activity. The following experiments were performed to determine the factors underlying the decrease in OH radicals.

The amount of OH radical exposed using 4Gy X-ray irradiation in the plasma of 98 volunteers (69 men and 29 women, ages ranging from 22 to 35 years old) was measured by ESR. We analyzed the relationships between the amount of OH radical and biochemical properties for the 98 volunteers by multivariate analysis. Correlations between the scavenging of OH radical and the total protein and albumin were observed using by the multivariate analysis. However, the existence of hepatitis B surface (HBs) antibodies had the greatest influence on OH radical- scavenging activity.

One volunteer who did not have HBs antibody was given an inoculation of the hepatitis B vaccine. The amount of OH radical generated by X-ray irradiation in plasma taken from the volunteer was observed for over a long time. There was a remarkable decrease of the amount of OH radical generated from plasma 7months after initial inoculation.

When the hepatitis B vaccine was used for plasma containing the HBs antibody, we observed agglutination with the hepatitis B vaccine and the HBs antibody. We examined whether the radical-scavenging effect of the HBs antibody remained when this agglutination was observed in vitro. Generation of OH radicals increased in plasma with the HBs antibody supplemented with the hepatitis B vaccine.

Our results indicate that the HBs antibody is an important factor for the scavenging of OH radicals initiated by X-ray irradiation in the human body.

ORAL PRESENTATIONS

IS THORON AN INFLUENCE QUANTITY FOR THE MEASURING RADON ACTIVITY CONCENTRATION INSTRUMENTS?

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Thoron, the isotope 220 of radon, is a radionuclide whose concentration may influence the measurement of the activity concentration of radon-222 in the air. If in the case of continuous and active sampling measuring instruments, using a pump for example, the influence of thoron on radon measurement is no doubt and is taken into account in the apparatus, it is often assumed that, in the case of a passive sampling, by diffusion through a filter for example, this thoron influence is negligible. This is coming from the very short radioactive half-life of thoron, 55.6 s (3.82 days for radon-222), and the assumption that the time diffusion of thoron in the detection chamber is long enough beside that of the thoron half-life.

The objective of this study is to check whether this assumption is true or not for different kinds of commercial apparatus used to measure radon activity concentration from soil to dwellings. A part of this study results will be presented. First of all, the devices were calibrated in activity concentration of radon, and then they were exposed to a controlled thoron atmosphere in the IRSN radon test bench called BACCARA. The experiments concerning the thoron aimed to investigate the sensitivity to thoron in the radon measuring mode of the apparatus. Results of these experiments show that all devices have a very quick answer to thoron atmosphere, even though the sensitivities vary from one instrument to another. Results clearly show that this influence on radon measurement due to the thoron is observed also after the exposition because of the decay of ^{212}Pb and its progenies.

In conclusion, the sensitivity to thoron in the radon measuring mode depends strongly on the type of instruments. The results of our investigation show that, for some apparatus, the influence of thoron cannot be disregarded especially when measuring radon in soil gas.

Keywords: radon, thoron, metrology, instrument response, influence quantity

REFERENCE INSTRUMENTS BASED ON SPECTROMETRIC MEASUREMENT WITH LUCAS CELLS

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The Bundesamt für Strahlenschutz (BfS, Berlin, Germany) and the Paul Scherrer Institute (PSI, Villigen, Switzerland) both operate accredited calibration laboratories for radon gas activity concentration. Reference instruments are used to determine the target radon activity concentration in the reference chambers traceable to national standards provided by primary calibration laboratories. Both BfS and PSI use Lucas Cells as detector in their reference instrumentation due to the low dependence of this detector type on variations of environmental conditions. As a further measure to improve the quality of the reference activity concentration, a spectrometric method of data evaluation has been applied. The electric pulses from the photomultiplier tube (PMT) coupled to the Lucas Cells are subjected to a pulse height analysis, thus rendering a pulse height spectrum. The stored pulse height spectra are analysed retrospectively to determine the reference value of the radon activity concentration. This approach allows compensating for fluctuations in the electric parameters of the instrumentation during a measurement.

The reference instrumentation of both laboratories is described with the respective spectrum evaluation procedures. The methods of obtaining traceability to the primary calibration laboratories of Germany and Switzerland and data of performance tests are presented.

MOBILE UNIT FOR SITE CHARACTERIZATION IN ENVIRONMENTAL REMEDIATION PROJECTS

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As part of an environmental remediation plan to be applied to areas affected by past activities and accidents, characterization of the site is a mandatory step. This activity will determine the extent of the contamination, contaminants' distribution, etc. Traditionally, this activity involves the collection of different environmental samples and laboratory analysis of the relevant radio nuclides (and eventually other contaminants like heavy metals). When the results are available they are interpreted and then a decision is made. This process is normally very expensive and time consuming. In recent years many techniques have been made available for in-situ measurement that can provide reliable information on the contamination profile in radiological contaminated land. Such measurements tend to be less expensive, faster and with the aid of GPS/GIS systems decisions can be made on-site in real time. Mobile units may also be useful to states who do have laboratory analysis facilities, but are faced with large, unforeseen characterization challenge, such as following and accident or radiation emergency. To overcome this situation we developed the DACM (Data Acquisition and Control Module) technology. Instruments based on this technology can be modified anytime by the user without special knowledge and the claiming of the manufacturer.

The DACM based offers a set of components which can be configured, parameterized and controlled with respect to the requirements on site. Typical components are Radon/Thoron modules, signal inputs for sensors like Co_2, Methane, So_2.., Nuclide identifying Gamma radiation module, Radioactive Aerosol analyzing module, control outputs for instance for pumps, magnetic valves for exhalation measurements but also complex functional blocks like spectrometers, GPS receiver, PID regulators etc. A complex sampling schedule can be created within few minutes by a graphical software interface.

The Data transmission and device control can be done by GPRS or GSM modems, as well as via ZigBee adapter (Wi-Fi), if the device is operated in inaccessible or contaminated areas.

One new developed version of this system is the NucScout as a handy and robust 2“ x 2“ (optional 3”x3”) NaI(TI) Nuclide Identifier and quantifier. With less than 2 kg including GPS and ZigBee wireless connection he can be so calibrated by use in 1 m high from the soil, that he show direct the nuclide activity in Bq/kg from up to 6 nuclides, which can be chosen from a big nuclide library with more than 50 nuclides. So you can get with a time resolution of 10 sec and a speed of 1 m/s a local resolution of 10 m and you can detect a specific activity less than 200 Bq/kg soil activity on the surface.

The device is so small that it is possible to use on a small UAV like Quadro- or Octocopter

INTERCOMPARISON EXPERIMENTS AS IMPORTANT FACTOR FOR QC/QA OF RADON AND THORON MEASUREMENTS

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Four independent institutions such as National Institute of Radiological Sciences, Chiba, Japan (NIRS), Public Health England, United Kingdom (PHE), National Radiation Protection Institute, Prague, Czech Republic (SURO) and Federal Office for Radiation Protection, Germany (BfS) are carried out intercomparisons exercises of passive radon (NIRS, PHE, SURO and BfS) and thoron (NIRS and SURO) monitors periodically.

The intercomparisons among laboratories performing the measurements for public are important to verify their quality assurance, reliability of results as well as comparability of the methods and instruments.

Because some of laboratories participate in all four intercomparisons it seems to be necessary harmonization and standardization of the final results. Therefore the proposal of standard protocol of data evaluation was drawn up.

DISCRIMINATION METHOD OF THE EFFECTS FROM ARTIFICIAL RADIATION IN ENVIRONMENTAL DOSE RATE MEASUREMENT

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The environmental dose rate is known to vary depending on natural phenomena such as rainfall, snowfall, and snow cover. By estimating the variation of natural radiation in environmental dose rate measurements, we have developed a method to discriminate the effects of artificial radiation.

The count rate of γ radiation (1.76 MeV, 2.20 MeV) emitted by the uranium series decay product Bi-214 increases due to rainfall or snowfall and exhibits a good correlation with the environmental dose rate. On this account, it is effective as an indicator for estimating the increment in environmental dose rate due to rainfall and snowfall. Furthermore, the variation in the count rate of γ radiation (2.62 MeV) emitted by the thorium series decay product Tl-208 due to rainfall or snowfall is minor; on this account, it is an effective indicator for ascertaining the decline in radiation from ground areas shielded by fallen snow. By making use of this fact, we estimate dose rates based on natural radiation, using a multiple regression formula with Bi-214 and Tl-208 count rates as variables, and discriminate the effects of artificial radiation by subtracting these estimated dose rates from the measured environmental dose rates.

As a result of applying this method to the monitoring of environmental radioactivity being carried out by Aomori Prefecture, we were able to ascertain the following environmental dose rate increasing phenomena.

・The contribution of Kr-85 released in accompaniment with the shearing and dissolving of spent fuels in the Active Tests conducted at the Rokkasho Reprocessing Plant

・The contribution of radioactive cesium−presumed to be traceable to the Tokyo Electric Power Company (TEPCO) Fukushima Dai-ichi Nuclear Power Plant accident−adhered to vehicles

In Aomori prefecture, the environmental dose rate can be less than 10 nGy/h on account of snow cover on the one hand, and more than 100 nGy/h due to rainfall or snowfall on the other. Under such conditions, this method can discriminate a contribution of around 1 nGy/h from artificial radiation.

SIMULTANEOUS DETERMIANTION OF BETA EMITTERS BY LIQUID SCINTILATION COUNTING PARTIAL LEAST SQUARES

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Liquid scintillation counting is meaningful technique for the determination of alpha and beta emitters. It has appropriate detection efficiency but poor resolution. This poor resolution hinders the simultaneous determination of different emitters in the same spectrum because of their overlapping. In the case of beta emitters this overlapping is unavoidable on account of their continuous spectra, caused by the disintegration energy distribution between electron and antineutrino. However, to achieve simultaneous determination of several beta emitters, by just one assay consisting of an easy amb fast sample treatment and subsequent measurement by liquid scintillation counting, makes it possible to avoid expensive and time consuming radiochemical separations. Because of this, several authors studied and proposed different approaches based on multiple windows definition, spectra deconvolution or chemometric techniques, to identify and quantify single isotopes in complex radionuclide mixtures.

In this work liquid scintillation spectrometry with Partial Least Square (PLS) calibration was used to determine different beta emitters (^{40}K, ^{60}Co, ^{90}Sr/^{90}Y and ^{137}Cs) in composite water samples. The isotopes selected cover a wide energy range of beta emissions (from 0.31MeV for ^{60}Co to 2.28 MeV for ^{90}Y).

The analytical procedure used is based on evaporate to dryness a 100 mL aliquot of the sample. The precipitated obtained is dissolved in 10 mL of deionised water acidified by HCl to pH=1.5. Afterwards 8 ml aliquot of this sample is mixed with 12 ml of Ultima Gold AB in PE vials. The vial is counted with the ultra-low level liquid scintillation spectrometer QUANTULUS 1220, after 2 hours remaining in darkness to avoid photoluminescence phenomena.

For each radionuclide three replicates for three different activity levels for were analysed. Furthermore, two quenching curves for both colour and chemical quenching were performed for each radionuclide. Both curves cover a range of SQP[E] values from 500 to 800. The calibration set was performed including the data of the entire single isotope and their quenching curves. Different data pre-treatment (including normalization and Savitzky-Golay smoothing filter) were tested in order to obtain the lowest error in cross validation.

In order to externally validate the PLS model, 12 composite spectra simulated by the addition of different single isotopic spectra were analyzed. The errors obtained for all the isotopes in each sample were, in all the cases, below 15 %.

NUCLEAR REGULATIONS OF NUCLEAR INSTALLATION AS A SOLUTION TO PREVENT NUCLEAR ACCIDENTS AND TO GET ACCEPTANCE OF PUBLIC IN INDONESIA

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Nuclear reactor accidents warn us to prevent nuclear accidents even though the nuclear installation is good enough such as Fukushima Daichi nuclear reactor accident and Chernobyl nuclear reactor accident. The occurrence of a nuclear accident cannot be absolutely ignored, that its danger could impose a risk of harms to humans, property, and environment. Thus, the public fear of nuclear reactors especially in developing countries such as in Indonesia and societies become antipathy with nuclear. Then, the nuclear development in Indonesia become obstructed. Based on the fact that it is necessary regulatory framework that ensures nuclear installation. The regulations should consider legal and technical factors. Consideration of technical factors in the operation of nuclear installations such as power utilization, nuclear materials characterization, and the possibility of nuclear accidents. Based on existing regulations in Indonesia which related to nuclear installation can be concluded that Indonesia has a good regulations but should be added a new regulations about nuclear installations. So that societies throughout Indonesia can accept nuclear technology.

POSTER PRESENTATIONS

CALIBRATION OF THE RADON MEASURING POLITRACK SYSTEM BASED ON SOLID STATE NUCLEAR TRACK DETECTION

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During the last 20 years, our laboratory used electret detectors routinely to measure indoor radon concentrations (IRC). To face recent national requirements of measuring exposures as low as 50 kBqh/m^3, i.e. the Swiss concentration average of 70 Bq/m^3 over a one-month period, we decided to move on solid state nuclear track detectors (SSNTD). Consequently, we acquired a Politrack SSNTD reading system (Miam, Italy) and CR39 films. This work aimed at the calibration of the Politrack system with traceability to international standards and the development of a device to check the stability of the system.

We exposed 300 CR39 films at 10 different radon exposures in the radon chamber of the Secondary Calibration Laboratory at the Paul Scherrer Institute, Switzerland. The exposures ranged from 50 kBqh/m^3 to 15000 kBqh/m^3. The expanded (k=2) combined uncertainty of the radon gas exposures in the chamber was between 1.8% and 3.6% of the target exposure. For each exposure, 5 detectors were used to monitor possible background exposures during transport and storage. We then determined the response curve and calculated the calibration factor of the whole system using a Monte Carlo fitting procedure. Furthermore, we determined the characteristic limits using the ISO Norm 11929.

To check the stability of the Politrack system, we developed a device to produce CR39 samples with a reference number of tracks. For this purpose, we irradiated CR39 films with a reference Am-241 source during a define time that is controlled by an automatic shutter. Stability of the system can then be monitored within 5% for routine measurements.

THE MEASUREMENT ACCURACY COMPARISION OF TWO DIFFERENT DOSIMETRY THERMOLUMINESCENT SYSTEMS

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The measurements accuracy for the thermoluminescence dosimetry systems is the most important parameter for institutions that offer services in the area of radiation dose determination. The topic of this paper is the comparisons of the measurement accuracy by two commercial thermoluminescence dosimetry systems. The first system is owned by the Institute of Occupational Medicine (IOM), Prishtina, Kosovo and the second is used by the Institute of Applied Nuclear Physics (IANP), Tirana, Albania. Both systems are used for dose measurements purposes, especially in the area of personal dosimetric monitoring

The first system is a Rados RE-2000, whith LiF:Mg,Ti cards, which was installed last year in IOM. The second system is a Thermofisher Scientific 4500 based on TLD-100 cards.

From each TLD system randomly was selected 10 dosimeters, and they were irradiated in the same conditions on X-ray beam. This procedure was repeated for four different input parameters of X-ray generator.

The obtained values were analyzed and compared with results from calibrated DAP meter which has been placed in the tube during all exposures.

Key words: measurement accuracy, themoluminescent dosimetry, radiation dose.

POSTER PRESENTATIONS

ESTIMATION OF KRYPTON-85 DISPERSION FROM THE SPENT NUCLEAR FUEL REPROCESSING PLANT IN ROKKASHO, JAPAN, USING AN ATMOSPHERIC DISPERSION MODEL

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Japan's first large-scale commercial plant for reprocessing spent nuclear fuel was located in Rokkasho, Aomori Prefecture, Japan, by Japan Nuclear Fuel Limited. Final tests of the plant operation with actual spent fuel began on 31 March 2006, and small amounts of radionuclides (mainly ^{3}H, ^{14}C, ^{85}Kr, and ^{129}I) have been discharged into the atmosphere from the main stack of the plant. From April 2006 to February 2009, environmental γ-ray dose rates were measured at the Institute for Environmental Sciences (located approximately 2.6 km east of the main stack), as well as at seven stations around the plant, which are monitored by Aomori Prefecture and Japan Nuclear Fuel Limited. Increases relative to background in γ-ray dose rates due to discharged ^{85}Kr were observed at the measurement points during the test operation period. The concentrations of ^{85}Kr in the atmosphere were also measured at the seven monitoring stations, and the Fifth-Generation Penn State/NCAR Mesoscale Model and CG-MATHEW/ADPIC Models (version 5) were used to estimate the dispersion of ^{85}Kr in the atmosphere.

The agreement between the estimated and measured γ-ray dose rates due to ^{85}Kr was evaluated in terms of the ratio of the number of estimated values that were within factors of 2 and 5 of the measured values to the total number of measured values. Factor of 2 and factor of 5 agreement ratios for estimated monthly mean γ-ray dose rates at the Institute for Environmental Sciences were 45% and 100%, respectively. At the seven monitoring stations, 30% and 78% of the estimated monthly mean γ-ray dose rates agreed with the measured rates within factors 2 and 5, respectively. However, for the monthly mean ^{85}Kr concentrations, the factor of 2 and factor of 5 agreement ratios were 13% and 39%, respectively; these ratios were smaller than those for the γ-ray dose rates. Further research, including a study of microscale advection, is necessary for better estimation of ^{85}Kr dispersion.

This study was performed under a contract with the government of Aomori Prefecture, Japan.

ORAL PRESENTATIONS

CHANGES IN AMBIENT DOSE EQUIVALENT RATES AROUND ROADS AT KAWAMATA TOWN AFTER THE FUKUSHIMA ACCIDENT

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After the Fukushima Daiichi Nuclear Power Plant accident, six vehicle-borne surveys were carried out under Japanese government-commissioned research projects until July of 2013. Changes in ambient dose equivalent rates through the vehicle-borne surveys have elucidated ecological half-lives of radioactive caesium in the environment. To confirm that the ecological half-lives are appropriate for predicting ambient dose equivalent rates within living areas, it is important to ascertain ambient dose equivalent rates on/around roads. In this present study, radiation monitoring on/around roads at Kawamata town located about 37km northwest of the Fukushima Daiichi Nuclear Power Plant was performed using monitoring vehicles and survey meters. It was found that the ecological half-lives evaluated using changes in ambient dose equivalent rates through the vehicle-borne surveys were useful for living areas located around roads since the ecological half-lives on roads were essentially consistent with those around roads. The ambient dose equivalent rates around roads were found to be higher than those on roads as of October of 2012. As basis of dose predictions using ecological half-lives, it is necessary to make corrections to ambient dose equivalent rates through the vehicle-borne surveys against those within living areas.

ISOTOPIC RATIO OF CS-135/CS-137 AS A NEW TRACER FOR SOURCE IDENTIFICATION AND LONG-TERM ENVIRONMENTAL BEHAVIOR STUDIES ON RADIOACTIVE CS RELEASED FROM THE FUKUSHIMA NUCLEAR ACCIDENT

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Since the Fukushima Daiichi nuclear power plant (FDNPP) accident in 2011, intensive studies on the distribution of released fission products, in particular ^{134}Cs and ^{137}Cs, in the environment have been conducted, and the activity ratio of $^{134}Cs/^{137}Cs$ has been widely used as a tracer for contamination source identification. However, due to the short half-life of ^{134}Cs (2.06 y), this tracer will become unavailable in the future. Here, we investigated heavily contaminated environmental samples (litter, lichen and soil) collected from Fukushima forests for the long-lived ^{135}Cs (half-life, 2x106 y) and the $^{135}Cs/^{137}Cs$ isotopic ratio. The determination of ^{135}Cs and ^{137}Cs in environmental samples was done using a newly developed ICP/MS/MS analytical method by combining AMP selective Cs adsorption and ion-exchange chromatographic separation techniques. For the first time, we obtained the isotopic composition of the $^{135}Cs/^{137}Cs$ isotopic ratio of the FDNPP-released radiocesium. We demonstrated that radiocesium was mainly released from the Unit 2 reactor. $^{135}Cs/^{137}Cs$ can be considered as a new tracer for source identification and long-term estimation of the mobility of released radiocesium in the environment.

ESTIMATION OF URANIUM AND CESIUM RADIO ISOTOPES IN UNDISTURBED SOIL AFFECTED BY FUKUSHIMA NUCLEAR POWER PLANT ACCIDENT AND THEIR MOBILITY BASED ON DISTRIBUTION COEFFICIENT AND SOIL PROPERTIES

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A catastrophic earthquake of magnitude 9.0 followed by Tsunami on 11 March 2011 caused serious nuclear accident at the Fukushima Daiichi Nuclear Power Plant (FDNPP) and contaminated soil over a vast area. There was a large release of radio cesium (Cs-134 and Cs-137) to the atmosphere and consequently contaminated soil due to fallout activity. In addition a large amount of contaminated water used for cooling the reactor vessel during the accident has been stored near the reactor, containing radioactive uranium along with other fission products. Now there is a major concern of leakage of this water through seepage to the aquatic systems. Long lived radionuclides deposited on soil can cause an enhanced radiation exposure even after many years and depending upon environmental conditions can be mobilized to aquatic systems. Therefore the assessment of the fate and transfer of these radionuclides in the soil water system is very important for radiation protection and dose assessment. In the present study emphasis has been given on the estimation of uranium and cesium radioisotopes in soil and their geochemical behavior in the respective site.

Soil and water samples were collected from contaminated areas around FDNPP. Inductively coupled plasma mass spectrometry (ICPMS) is used for total uranium concentration and for uranium isotopes thermal ionization mass spectrometry (TIMS) have been used as the measurement tool. Ion exchange followed by extraction chromatography has been used for uranium isotopic separation. Gamma spectrometry has been used for estimation of radio cesium. High Cs activity has been observed in the areas in the plume direction observed during the accident. U-235 and U-238 ratio shows of natural origin, however in few samples U-236 has been detected. For the migration behavior, distribution coefficient (Kd) has been determined for these radionuclides experimentally and the effect of soil and water parameters on it has been studied. Additionally vertical profile of Cs activity has been measured and these profiles has been analysed to state the behavior of Cs in soils and after that by using a convective diffusive model, the parameters of the model governing the vertical migration have been evaluated. The generated data will be useful for long term predictions of activity depth profiles.

ANALYTICAL METHOD DEVELOPMENT OF SR-90 MEASUREMENT IN SOIL SAMPLES AFFECTED BY THE FUKUSHIMA NUCLEAR ACCIDENT

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There is an increasing interest on Sr-90 measurement in environmental samples after the Fukushima Daiichi nuclear power plant (FDNPP) accident since it is a bone seeker isotope with high toxicity. Radioactive strontium, cesium and plutonium isotopes are the main contributors of radioactive contamination for many years after FDNPP accident due to their longer half-life. Radiocesium (Cs-137, Cs-134) deposition is significantly high over a large area in Japan owing to the FDNPP accident. Consequently, the presence of radiocesium in environmental samples collected from contaminated fields is obvious.

Sr-90 is a pure beta emitter radionuclide thus separation from self-absorptive sample matrix and other disturbing beta emitter radionuclides is required. Most of the Sr-90 separation methods are based on precipitation, liquid-liquid extraction, ion-exchange chromatography and extraction chromatography. Recently extraction chromatography using selective Sr resin is the most popular method since it is easy to handle and simple to use. Disadvantages of the Sr resin, such as strontium retention decrement in the presence of elevated amount of calcium, high lead and tetravalent actinides retention are well known and overcome.

In our work, Sr-90 specific activity were analysed in soil samples affected by FDNPP accident. Each sample had elevated radiocesium specific activity, the average of Cs-134 was 46 (5.5-120) Bq/g while the average of Cs-137 was 91 (11-230) Bq/g, respectively. The perfect separation of radiocesium from Sr-90 is a cardinal point to gain accurate Sr-90 result as the radiocesium also undergoes beta decay emitting gamma-rays. Furthermore, there is another problem, i.e. of high iron concentration in Japanese soils.

In our laboratory, an efficient separation procedure was established to remove radiocesium and iron from soil samples to produce required samples for a liquid scintillation counter. In addition to radiometric detection methods, mass spectrometric methods show excellent prospects in nuclear measurements techniques. Thus, separation procedure development has been aimed for thermal ionization mass spectrometry.

ESTIMATION OF RADIOCESIUM DEPOSITION AMOUNT IN KOREA FOLLOWING THE FUKUSHIMA NUCLEAR ACCIDENT

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To assess radiological impact in Korea following the Fukushima nuclear accident on March 12, 2011, radiocesium deposition amount was estimated. After April, 2011, ^{134}Cs and ^{137}Cs was observed simultaneouly at 12 regional monitoring stations, and the highest activity concentrations in rainwater samples were 0.330 ± 0.029 and 0.335 ± 0.034 Bq/L, respectively, at Jeju province on April 19, 2011. Estimated ^{134}Cs deposition amounts ranged from 0.31 to 25.2 Bq/m^2 by using precipitation data, adimistrative district area and radiocesium concentration in wet deposition samples taken during 2011 in 12 regional monitoring stations. Meanwhile, the range of ^{134}Cs deposition amout estimated by the soil samples analysis were 0.42 – 1.14 Bq/m^2. The difference between two values can be acceptable if considering the uncertainties of runoff by rain water, sampling, radiological analysis, etc. Meanwhile, as a result of ^{134}Cs and ^{137}Cs deposited in ground, ^{134}Cs and ^{137}Cs were simultaneously detected in some gray mullet samples collected in southeast and south coast during 2012 ~ 2013. The maximum concentrations of ^{134}Cs and ^{137}Cs were respectively 4.99 ± 0.05 Bq/kg-fresh and 7.08 ± 0.06 Bq/kg-fresh.The ratio of ^{134}Cs and ^{137}Cs in gray mullet samples was 0.64 – 0.70 in 2012 and 0.36 – 0.53 in 2013. However, in other fish samples , no ^{134}Cs was detected whereas ^{137}Cs was in the normal range (n.d. – 0.174 mBq/kg-fresh).

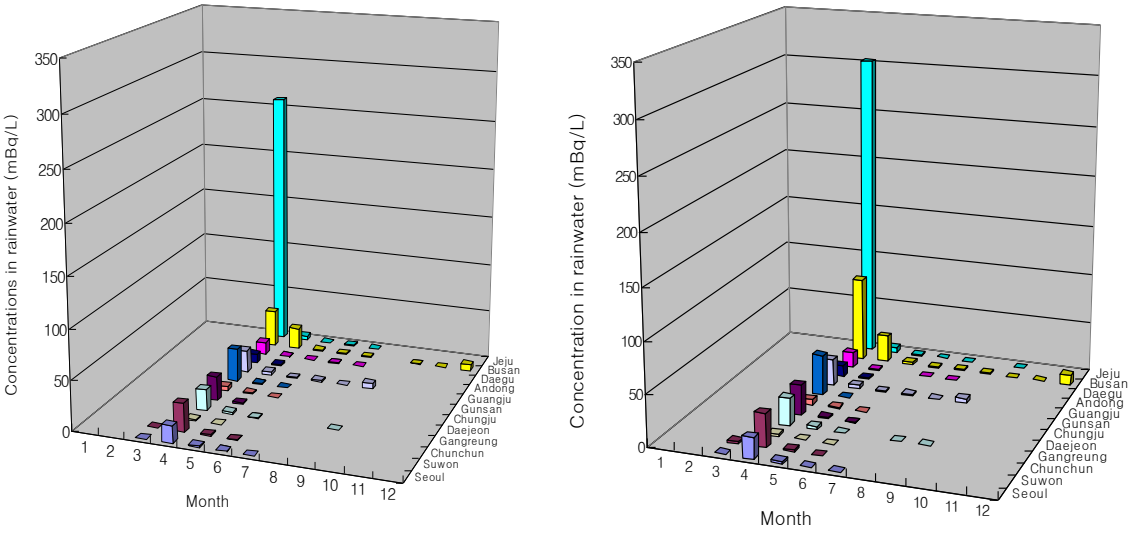

Figure 1. Monthly variation of ^{134}Cs in rainwater samples collected at 12 regional monitoring stations, left): ^{134}Cs and right); ^{137}Cs.

EXTREME VARIATIONS OF DOSE RATES IN EAST FUKUSHIMA

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Immediately after the tragic nuclear accident that took place at the Fukushima Daiichi Nuclear Power Plant [FDNPP] in the middle of March in 2011 nationwide monitoring efforts of air dose rates among others started in Japan. Especially intensive monitoring was performed in eastern Fukushima area that was the most seriously contaminated by various radioactive nuclides emitted from the FDNPP. Among the many measurement points 161 points in eastern Fukushima prefecture were selected to analyze their time evolution during June 10th and December 5th when radioactive Cs became dominant. In the present study nine points that showed the most extreme variation rates among the 161 data sets were chosen as shown in Table 1, and analyzed. Out of the nine points five (three) are the data that showed the most rapid decrease (increase). The remaining single data showed an unusually rapid decrease during the summer and an increase during the following fall. The possible mechanisms for the rapid rise and/or fall in dose rates were analyzed based on meteorological conditions and local geography that were supplemented by actual field studies. In the meantime, the points of rapid decrease correspond to sources of contamination; namely, dose rates decreased owing to effectively draining radioactive materials toward elsewhere. On the other hand, the points of rapid increase correspond to receptors of contamination, which tend to effectively absorb radioactive materials from elsewhere. It was found that the effectiveness of the flow of radio-materials is mediated by principally two geographical factors, i.e., the presence of pavements and/or slopes. At times the presence of buildings may affect dose rates, shielding winds that tend to spread radio-materials. When these factors are combined the effectiveness is optimized, resulting in large temporal variations in dose rates as presented here. Furthermore, strong variations are mediated by two meteorological entities, i.e., precipitation and wind. These manmade and natural factors tend to predominantly control air dose rates. However, judging from these examples, the effects due to precipitation usually appear more outstanding, if any, than those due to winds. This kind of research would be useful for effective performance of decontamination efforts among others.

NUMERICAL SIMULATIONS OF ATMOSPHERIC DISPERSION OF IODINE-131 EMITTED FROM A POINT SOURCE

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Several dispersion models have been developed to simulate the transport, physical and chemical transformation of the radionuclides in the atmosphere. Verification and development of models is crucially important for both model developers and users. At the same time model verifications are generally confined only to accidental releases (e.g., after Fukushima event in March, 2011). However, normal operating or controlled releases could also be suitable for model verification. In this study, the atmospheric dispersion of iodine-131 emitted to the atmosphere in extremely low concentration during an industrial process was simulated by different models, namely the TREX Eulerian model, the HYSPLIT Lagrangian model, and the PyTREX Lagrangian model. Model results were compared with available measuring data. Although only very limited data of measured iodine-131 concentration were available, the accuracy of modeled plume direction and the magnitude of the simulated iodine concentration in case of different models were analyzed. Results underlie the importance of detailed spatial and temporal resolution of meteorological fields and appropriate model parameterizations used in dispersion models, especially in case of complex weather situation.

POSTER PRESENTATIONS

APPLICATION OF A CZT DETECTOR TO IN SITU ENVIRONMENTAL RADIOACTIVITY MEASUREMENT IN FUKUSHIMA AREA

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Instead of conventional Ge semiconductor detectors and NaI(Tl) scintillation spectrometers, an application of a CZT whose crystal has the dimension of 1 cm cubic semiconductor to the in-situ environmental radio-activity measurement was attempted in deeply affected areas in Fukushima region. In the environments with the ambient dose equivalent rate below 1 μSv h^{-1}, in-situ environmental measurement using Ge detectors is quite powerful methods due to high sensitivity and resolution of peaks to gamma-ray from natural and anthropogenic radioactive materials. However, in deeply affected areas, for instance, in areas whose dose rates exceed 10 μSv h^{-1}, it turns out to be impossible to properly distinguish events in pulse height spectra obtained by Ge detectors. This is because conventional Ge detectors have so high sensitivity to gamma rays that each peak broadens in obtained pulse height spectra. A CZT detector does not have such a high resolution of peaks, comparing a Ge detector. However, it is found that a CZT has enough characteristics to properly determine radio-activity of ^{134}Cs and ^{137}Cs in soil, throughout the in-situ measurement campaign in deeply affected area within 20 km from the Fukushima Dai-ichi Nuclear Power Plant. In addition, in-situ environmental measurements were well implemented even under areas where dose rates exceed 50 μSv h^{-1}. Results of radioactivity concentration in soil ranged between 1 and 500 kBq m^{-2} and seem consistent to those obtained by the air-borne measurement. Discussion on environmental dose rates obtained from pulse height spectra by a CZT detector will be also done in the presentation.

SPATIAL CORRELATION STRUCTURE AND ANOMALIES OF DOSE RATE IN THE ZONE AFFECTED BY THE FUKUSHIMA NPP DISASTER, OBSERVED BY AIRBORNE SURVEY SHORTLY AFTER THE ACCIDENT

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We present a geostatistical analysis of data of dose rate and estimated ^{134}Cs and ^{137}Cs deposition density acquired by the US-DOE through an airborne survey in April and May 2011, i.e. shortly after the accident (11 March) and the subsequent releases (until the first days of April). We show variograms and interpolated surfaces as well anomalous structures traceable to observation uncertainty. The matter of resolution versus smoothing for airborne data, i.e. originating in a remote sensing technique, is also addressed.

The deposition pattern is very patchy, which is no surprise in view of previous experience of spatial fallout distributions. We present an analysis of "patchiness" based on multi-fractal reasoning and local anomaly detection. If scaling properties of spatial structures can be discovered, it may be used to probabilistically estimate structures below sampling resolution which is naturally limited, in different ways, for both remote sensing and point sampling techniques.

THE CHEMICAL FORM OF "ORGANIC" RADIOCESIUM IN SOIL AND SUSPENDED MATTER

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Significant quantities of radionuclides including Cs-134 and Cs-137 were released into the environment because of the TEPCO Fukushima Daiichi Nuclear Power Plant (FDNPP) accident in 2011. This caused serious damage to agricultural products in Fukushima. The physiochemical form of a radionuclide is an important factor in determining the fate of the radionuclide in the agricultural environment. The major forms of radiocesium in soil are exchangeable, clay-bound, and organic. Exchangeable radiocesium is likely to be absorbed into crops, whereas clay-bound radiocesium is strongly bound to soil clay minerals, and it is not considered to be available for crops. "Organic" radiocesium is defined as the fraction that it is not extracted by salt solution but should be solubilized by oxidative decomposition or alkali extraction. In our previous study, organic radiocesium was observed not only in soil but also in the suspended matter of streams. However, the mechanisms by which cesium ions bind with organic matter, the kinds of organic matter that bind with cesium ions, and whether cesium ions bind with organic matter at all remain unknown. In the present study, we aimed to clarify the actual chemical form of radiocesium extracted in the organic form from soil and suspended matter and the kinds of organic matter that bind with radiocesium. Soil samples were collected from relatively highly contaminated paddy and forest areas of Date City and from paddy and upland field soils in an evacuation area of Okuma Town, Fukushima. Suspended matter samples were collected from the irrigation water introduced near a stream in Date City and Okuma Town using a continuous centrifugal. The organic matter in soil and suspended matter were separated by density fractionation. Moreover, radiocesium in soil, suspended matter, and each fraction of organic matter were fractionated using several chemical preparations. Cs-134 and Cs-137 in each fraction were determined using a germanium semiconductor detector. The proportion of radiocesium fractionated in the organic form in soil varied between samples. The proportions of organic radiocesium in suspended matter were a small percentage of the total radiocesium and were less than those found in soils.

CESIUM CONCENTRATIONS IN SHELL OF JAPANESE MITTEN CRAB AROUND FUKUSHIMA DAIICHI NUCLEAR POWER PLANT

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After an accident of the Fukushima Daiichi Nuclear Power Plant of March 11, 2011, the environmental pollution by outflow of radioactive material to the ocean is acknowledged as a problem. In addition, it gives a citizen anxiety because radioactive material is taken in marine products by this accident. In this study, we obtained shells of Japanese Mitten Crab from 12 estuaries where around the Fukushima Daiichi Nuclear Power Plant. The obtained shells were crushed, and measured these radioactivities with a high-purity germanium detector. The dose rates in air were measured at 23 locations with a CsI(Tl) scintillation survey meter. A pocket survey meter was positioned 5 cm and 1 m above the ground surface. The highest radioactivity (^{134}Cs: 132 Bq/kg, ^{137}Cs: 305 Bq/kg) was measured at estuary of Tomioka river which is located at 9 km south area from the Fukushima Daiichi Nuclear Power Plant. In the same location, the highest dose rate in air at 5 cm and 1 m above the ground surface were measured to be 1393.8 nGy/h and 1780.0 nGy/h, respectively. The minimum dose rate in air at 5 cm and 1 m above the ground surface were 66.3 nGy/h at Same river and 62.5 nGy/h at Nigorigawa, respectively.

INFLUENCE OF FUKUSHIMA DAI-ICHI NUCLEAR POWER PLANT ACCIDENT ON ENVIRONMENTAL RADIOACTIVITY RESEARCH IN AOMORI PREFECTURE

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Environmental radioactivity surveys currently undertaken in Aomori Prefecture include environmental radiation monitoring in the vicinity of nuclear power plants as well as measuring environmental radioactivity level throughout the entire prefecture. These surveys have detected radioactive nuclides with short half-lives such as I-131 and Cs-134 in some environment samples, in accompaniment with the Tokyo Electric Power Company (TEPCO) Fukushima Dai-ichi Nuclear Power Plant accident that occurred in March 2011. In addition, the concentrations of Cs-137 and Sr-90 were also observed to increase. However, none of the concentrations exceeded the limits for air and water outside of environment surveillance area that are prescribed in laws and ordinances, standard values that are prescribed in the Food Sanitation Act and provisional permissible levels for pasture. Gross-β radioactivity concentrations in air dust and I-131 concentrations in air in the vicinity of Rokkasho village and in Aomori City were seen to rise more than two weeks after the accident, in early April and late April. Upon investigations based on backward trajectory analysis, we estimated that during this period, the atmosphere present in the survey area had flowed in via the vicinity of the TEPCO Fukushima Dai-ichi Nuclear Power Plant, whereas this had not been the case from immediately after the accident until prior to this period. The I-131 concentration in fallout sampled on a daily basis in Aomori City was observed to peak in late April. WSPEEDI operated by the Japan Atomic Energy Agency estimated I-131 fallout in the vicinity of Aomori City during this period. Cs-134 and Cs-137 concentration ratios in agricultural products, indicator organisms, and seafood after correcting for decay from the day of the accident were practically equal to one, and this agreed with the findings of a survey of radioactive substances in the vicinity of the Fukushima Dai-ichi Nuclear Power Plant carried out by the government.

RADIOACTIVE CESIUM OF FUKUSHIMA DAI-ICHI NUCLEAR POWER PLANT ACCIDENT IN LAKE AND COASTAL SEDIMENTS OF NORTHERN AND WESTERN JAPAN

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The Great East Japan Earthquake and subsequent tsunami on March 11, 2011 caused the Fukushima Dai-ichi Nuclear Power Plant (FDNPP) accident. As a result, large amount of radionuclides were deposited to river catchments in Fukushima area. Lakes and reservoirs are sinks of eroded materials including radionuclides from the catchment. Monitoring of river and lake sediments in Fukushima and adjacent areas has been undertaken as a matter of urgency. However, deposition record of lakes and reservoirs far from Fukushima area is limited. This study aims to reveal the deposition of radioactive Cs from FDNPP to lakes, reservoirs, and coastal sediments in northern and western Japan.

Study sites are 7 lakes in Hokkaido (Lake Akkeshi and Lake Onuma), Toyama Prefecture (Lake Dojo-ike), Ishikawa Prefecture (Takidani-ike Reservoir, Bishaguso-ike Reservoir, Lake Kiba-gata), and Shiga Prefecture (Lake Yogo). Coastal sediments in two semi-closed bays (Mutsu Bay in Aomori and Nanao Bay in Ishikawa) were also investigated. The distances of these sites from the FDNPP are about 320 km to 700 km. Samples used here were obtained using gravity core sampler and sediment trap during April 2011 to May 2013 after the accident. Sediment cores were sliced and surface sediment samples were analyzed. The activity concentration of and 134Cs, 137Cs, and excess 210Pb were determined by gamma-ray spectrometry using low background Ge detectors.

^{134}Cs derived from FDNPP was detected in 5 study sites (Lake Akkeshi, Onuma, Dojo-ike, Takidani-ike, and Nanao Bay). The concentrations of ^{134}Cs of these samples range 1.9–9.0 Bq/kg. To evaluate the effective factor of ^{134}Cs deposition in these sites, topographic conditions of lake-catchment systems, hydrological conditions, and fallout inventory were investigated. The ^{134}Cs-detected lakes roughly corresponds to the lakes with large catchment to lake area ratios (C/L ratio >20), indicating that materials from the catchment are concentrate in the lake. In contrast, ^{134}Cs was not detected in Bishaguso-ike Reservoir and Lake Kiba-gata, although they have relatively large C/L ratio. This may be attributed to the gentle slope topography in these catchments. These results suggest that topographic settings of the lake-catchment systems affect the accumulation of radioactive Cs in the lake sediment.

COLLABORATION OF LOCAL GOVERNMENT AND EXPERTS RESPONDING TO INCREASE OF ENVIRONMENTAL RADIATION LEVEL DUE TO THE NUCLEAR DISASTER 1. BACKGROUND STATUS AND OUTLINE OF COUNTERMEASURE OF KASHIWA CITY

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Background status and outline of countermeasure of Kashiwa city in Tokyo metropolitan area responding to the increase of environmental radiation level due to the Fukushima Dai-ichi Nuclear Power Plant (NPP) disaster were introduced as the introductory information for the five series presentations. Kashiwa city is a local government in Japan and located roughly 200 km away southward from the NPP. No preparation for disaster prevention in the city for any nuclear accident of NPP before the disaster. In addition, in the period of a few months immediately after the disaster, little support on environmental surveys or countermeasure guidelines from the national government had been provided because the city was outside of Fukushima prefecture. Kashiwa city started officially and from an independent standpoint to survey the environmental radiation status in response to requests from their citizens. The radiation surveillance in this area has been conducted and technically guided by radiation protection experts. The activity in the early stage has been based on the agreement decision of a local forum among six cities in the northwest part of Chiba prefecture including Kashiwa city and Nagareyama city. The six local governments established a new organization named CRCT, “Conference on Radiation Countermeasures in the Tohkatsu area”, to solve the common problems due to the disaster officially and in cooperation. Three experts of radiation protection, radiation measurement and medical science in the radiation field are also involved in the conference as supporting members for its activity. We think this is a preparation step or first step toward the real stakeholder engagement and involvements procedure for the optimization of protection through a collaboration of local governments and experts.

COLLABORATION OF LOCAL GOVERNMENT AND EXPERTS RESPONDING TO INCREASE OF ENVIRONMENTAL RADIATION LEVEL DUE TO THE NUCLEAR DISASTER 2. VIEWPOINT ON THE EFFECTS OF RADIATION EXPOSURE ON LOCAL RESIDENTS

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After Fukushima nuclear power plant (FNPP) accident, some "hot spots" were found in Tokatsu area in Chiba prefecture. Although ambient radiation dose at these hot spots was slightly increased compared to the surrounding areas, it was too low to harm residents' health conditions. But, residents in this area were excessively worried about effects of radiation exposure because Japan is the only country that was attacked by atomic bombs and it seems Japanese are very sensitive to issues on radiation exposure. Further exacerbating the public sentiment, misleading information was broadcasted by those who are not familiar with radiation exposure issues. For example, it was publicized that the morbidity rate of fatal cancer among young people in this area will dramatically increase even by slightly increased radiation exposure dose. These groundless negligent rumors further enhanced residents' anxiety. Radiation specialists including radiologists played some active roles in collaboration with staff from local governments to reduce social anxiety stemming from radiation exposure issues. They provided local residents with accurate information on radiation effects and health conditions through public meetings. They also had opportunities to discuss with parents of small children at kindergartens and nurseries. As for medical issues, radiologists who are familiar with effects of radiation exposure on human bodies were consulted at the public health center in Nagareyama city. Questionnaire revealed that these activities, especially those in small groups or via personal communication, were effective. Our experience indicated that radiation specialists are requested to offer accurate information on radiation exposure issues to the public to avoid their unnecessary panic reaction. On a long-term basis, educating radiation exposure effects on health conditions at local schools would be fundamentally important.

COLLABORATION OF LOCAL GOVERNMENT AND EXPERTS RESPONDING INCREASE OF ENVIRONMENTAL RADIATION LEVEL DUE TO THE NUCLEAR DISASTER 3. VIEWPOINT ON AMBIENT DOSE SURVEY AND FOODSTUFF INSPECTION

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Based on the guideline determined by the CRCT, "Conference on Radiation Countermeasures in the Tohkatsu area", the ambient dose rate has been monitored in Kashiwa city. The latest dose distribution data at the height of 5 cm (for identifying contaminated areas), 50 cm (for dosimetry of children) and 100 cm (for adults) from the ground in the cities can be seen against the background of a Google map on the local government web-pages. The highest value of the ambient radiation dose after the start of survey of May of 2011 was 0.65 μSv h^{-1} at the height of 1 m from the ground among all of the monitoring points. In addition, electric personal dose meters were given to a representative staff in each school, and the meters were worn at the chest height of a typical child. This shows a representative of a child's personal dose. Local governments were also strongly encouraged to monitor the specific radioactivity (Bqkg^{-1}) of local food and drinking water under the present popular policy of "Local Production for Local Consumption" in Japan. The sampling procedures of local foodstuffs are also determined by the discussion with some experts. An outdoor bamboo shoot sampled in the city on April 9, 2012 showed 170 Bq kg^{-1} as the specific radioactivity of $^{134+137}$Cs. In addition, a crucian carp sampled in a lake Teganuma on June 23, 2012 showed 241 Bq kg^{-1}. Specific radioactivity of all surveyed samples, other than these two, has been below the concentration limits determined by the government of Japan. Based on the data of 635 foodstuffs circulated from October of 2011 to September of 2013, a plausible maximum annual internal exposure dose from daily diet was estimated using information from the report of Ministry of Health, Labour and Welfare and ICRP Publication 72.

Key words: The Fukushima dai-ichi nuclear power plant disaster, Kashiwa city, ambient dose, specific activity, foodstuff, internal exposure dose

COLLABORATION OF LOCAL GOVERNMENT AND EXPERTS RESPONDING INCREASE OF ENVIRONMENTAL RADIATION LEVEL DUE TO THE NUCLEAR DISASTER 4. VIEWPOINT ON SURVEY AROUND WATER ENVIRONMENTS

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Data of specific radioactivity on Cs134+137 in and around water environments, for example in lakes, ponds or retention basins in Fukushima prefecture, have already been reported and shown officially or unofficially. However, systematic data of these water environments around the Tokyo metropolitan area have been reported little. This study is focusing on this area. We measured specific radioactivity of soil at the bottom of a retention basin in Kashiwa City, Chiba prefecture. Retention basin is an artificial small pond to be systematically surveyed and to be easily analyzed on its environmental variation. We selected Matsugasaki retention basin to be surveyed.

A main instrument used in this study was a NaI (Tl) spectrometer developed for the purpose of in situ measurement in underwater environments, AT6104DM (ATOMTEX, Belarus). Number of the measurement points selected in the basin were 26. We mainly surveyed specific activities of soil at the bottom of the basin in addition to dose rates around 0cm/50cm depth from the water surface. These in situ data were compared with the values which were measured by the standard method using the dried soil samples. Determination procedure of detection efficiency of the in situ spectrometer and effect of the water shielding between the detector and the bottom soil were discussed and estimated.

The specific radioactivity of the soils were estimated as several thousand Bq kg-1 or much more. Large difference on distribution of the activity in the basin has also been shown. Political countermeasure on the bottom soil should be discussed and determined based on these data of bottom soil in addition to the ambient dose around the basin and residents opinion.

CONTRIBUTION OF FUKUSHIMA DAIICHI NUCLEAR POWER PLANT ACCIDENT TO OKHOTSK SEA

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We have collected sinking particles by time-series sediment traps at Tokoro Bay in Okhotsk Sea from April 2011 to September 2012. Extremely low concentration of radiocesium (134Cs, 137Cs) derived from the Fukushima Daiichi Nuclear Power Plant (FNPP1) accident was still reported in Soya warm current affected by radioactive nuclear species falling down the Japan Sea from air after the accident. In this study, we will measure the extremely low radioactivity of radiocesium in the sinking particles using the low level radioactivity measurement system at Ogoya Underground Laboratory of the Low Level Radioactivity Laboratory (LLRL) of Kanazawa University, Japan. We evaluate the contribution of the FNPP1 accident occurred on 11 March 2011 to directly Okhotsk Sea and discuss the removal rate of sinking particle in the coastal area.

MIGRATION OF RADIOACTIVE CESIUM CONTAINING IN GRASS OR FALLEN LEAVES TO WATER

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Radioactive Cs emitted by the accident of the TEPCO Fukushima Dai-ichi Nuclear Power Plant was brought on the ground by rain and snowfall in March 2011. There was also Cs deposition to the surface of leaves in forests at that time. Moreover, after the deposition, trees and grasses are absorbing radioactive Cs in soil through their roots. It is known that when soil is dipped in water, hardly eluting for the strong adsorption to clay mineral of radioactive Cs. The decontamination work is progressing now, and dried grass and fallen leaves are also collected as decontamination waste. It is thought that it is important to evaluate the amount of elution of radioactive Cs at the time of soaking grass and fallen leaves in water by such a situation.

Some samples, clover, dandelion, and mugwort were extracted at the Yamakiya elementary school in Kawamata-machi, Date-gun, Fukushima-ken in May, 2013. Fallen leaves were also extracted in the wood which adjoins the school. The extracted samples were air-dried. About 15 g was put into U-8 container, respectively, and radioactive Cs concentration was measured using the hyperpure germanium semiconductor detector (HPGe detector). The sample which measured concentration was put into the bag made of a nonwoven fabric, and it soaked in 500-cc water for a long period of time. The soak was started on July 2, 2013. It put on room temperature. The water after soaking was filtered. Then, it was checked the weight, and was dried with a mantle heater. Furthermore, after collecting using a small amount of water and moving it to U-8 container, moisture was evaporated with the infrared oven. And radioactive Cs contained in the created sample was measured with the HPGe detector.

The radioactivity of Cs-137 before soaking was 5.9 Bq, 3.0 Bq, 18.6 Bq, 102 Bq, and 369 Bq, respectively for clover, dandelion, mugwort, fallen leaves (broad leaf), and fallen leaves (needle leaf). The amount of Cs-137 eluted by the soak for 8 or10 days are 1.87 Bq, 0.45 Bq, 3.65 Bq, 5.52 Bq, and 4.83 Bq, respectively, and there were no 10 times as many differences in the concentration contained in 500-cc water. The leaching rates were 0.32, 0.15, 0.19, 0.05, and 0.01 as a result. Fallen leaves were as small as 0.01-0.05 to grass having been 0.15-0.32.

FACE THE FEAR IN FUKUSHIMA

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Over and above the radiation protection approach, the Fukushima accident has brought unexpected societal problems to the surface. As a consequence of failed public relations, the public in Japan do not trust the government and the scientists. Fear stalks them. Despite the vast amount of research on nuclear energy, little is known about its effect on human social behaviour. Because of this fear people do not accept the conception of ALARA (As Low As Reasonably Achievable), and they demand total decontamination, which has an extremely high economic impact. An overall negative image emerges from the news and past negative experiences such as atomic bombings of Hiroshima and Nagasaki, the Chernobyl accident; and in this the behaviour of people reflects irrational instead of rational behaviour. A newly developed socio-economic model, applied to study this nuclear aversion, emphasizes the need for rationality in handling the aftershock of the Fukushima crisis. According to the model results, this nuclear fear could be eliminated by improving one's self-control level and the knowledge on radiation protection.

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●概要

■ NaI(Tl)検出器採用の「EMF211型γ線スペクトロメータ」に新世代のCeBr3（セリウムブロマイド）検出器が加わりました。

■ GPS付高感度γ線スペクトルサーベイメータやγ線モニタリングポストとして使用可能な2種類の日本語ソフトを付属。

■ G(E)関数によりスペクトルから空間線量率（μSv/hおよびnGy/h）を算出。「環境放射線モニタリング指針」に沿って測定し、自動記録できます。

●特長

■ 大型2インチ・3インチの高分解能CeBr 3(セリウムブロマイド)シンチレーション検出器を採用したため、高感度でシャープなスペクトル測定が可能になりました。

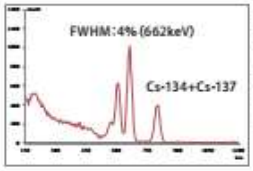
■ 専用ソフトをインストールしたタブレットPC（Windows8.1）を付属し、USBケーブルで接続するだけで使えます。

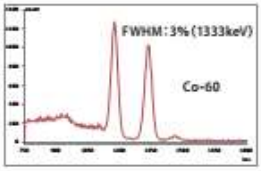
■ 温度補償機能搭載により温度変化によるエネルギー変動が少なくなりました。

■ LaBr3（ランタンブロマイド）よりローバックグラウンドで、NaI(Tl)より高線量率が測定できます。

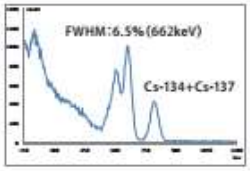
●NaI(Tl)検出器とのスペクトル比較例

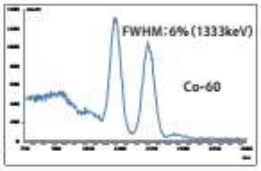
■ CeBr3 検出器（2インチ）





■ NaI(Tl)検出器（2インチ）





NaI(Tl)シンチレーション検出器採用 空間線量測定システム

EMF211型γ線スペクトロメータ

●概要

■ 大型2インチ・3インチのNaI(Tl)シンチレーション検出器を採用したシステムで上記のCeBr3 検出器と同様に2種類のソフトが使用できます。

■ お求めやすい価格で正確なスペクトル測定と線量測定が実現できます。（エネルギー範囲：0.03～3MeV、線量率範囲：0.001～50μSv/h）

■ 大学や研究機関などへ90台以上の納入実績があります。

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iTQi
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優秀味覚賞
AWARD
2014
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