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Sessions:

- **Session 1 - Radiation risk at nuclear legacy sites: assessment, remediation and regulation**

G. Hirth (ARPANSA), T. Yankovich (IAEA)

- **Session 2 – NORM and TENORM with respect to long-term human and environmental protection**

B. Michalik (GIG), H. Vandenhove (SCK•CEN)

- **Session 3 – Fukushima- and Chernobyl-driven evolution of post-accident environmental recovery preparedness and management**

W. Raskob (NERIS platform), M. Tamaoki (NIES)

- **Session 4 - Evolving issues in the emerging nuclear landscape: fusion, Gen 4 reactors, SMRs, dismantling, radioactive waste management and consideration of environmental impacts**

T. Lazo (OECD-NEA), S. Sheppard (Journal of Environmental Radioactivity Editor)

- **Session 5 - Application of novel methods used for monitoring and radioecological studies**

T. Ikaheimonen (STUK), W. Rühm (EURADOS platform)

- **Session 6 - Advances in radioecological modelling approaches to support regulation and underpinning databases**

N. Beresford (NERC-CEH), V. Kashparov (NUBiP)

- **Session 7 - Dynamics and distribution of radionuclides in the environment and underlying processes**

M. Steiner (BfS), A. Real (CIEMAT)

- **Session 8 - Mechanistic understanding of the effects induced by ionising radiation in non-human species alone or in combination with other stressors**

S. Geras'kin (RIARAE), S. Salomaa (MELODI platform), P. Yu (City University of Kong-Kong), M. Tamaoki (NIES)

- **Session 9 - Dissemination of scientific information to the public and risk communication**

S. K. Jha (BARC), P. Yu (City University of Hong-Kong), K. Higley (Oregon State University)

P2-10

Recognition of health geohazard of thoron (Rn-220) exhalation into room air of earthen dwellings in northern Vietnam

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Introduction

Low-cost housing construction in developing countries often relies on the use of local soil or clay that is compacted and dried to form the walls of dwellings (Fig. 1). Depending on the local geological context, the soil and clay building materials may contain enough thorium and uranium to produce significant exhalation of radon isotopes. Unlike their metallic precursor elements, monoatomic noble gas radon can diffuse into the room air where it can be inhaled by humans, dissolve in lymph fluid, and pose a radiation health hazard not only due to radon's own radioactive decay, but also due to the subsequent radioactive decay chains of their unstable metallic daughter nuclides in the human body (WHO, 2009).

Fig. 1: Traditional mud house in northern Vietnam

Among all radon isotopes, traditionally only ^{222}Rn and its progeny have been considered a health risk in indoor environments due to (i) their contribution to the overall radiation dose and their potential for inducing lung cancer, (ii) widespread occurrence in buildings in developed countries, and (iii) because ^{222}Rn is relatively easy to quantify in room air. In contrast, the contribution of ^{220}Rn (called thoron) to the radiation dose in room air has not received sufficient international attention, in spite of pioneering research in China, Germany, Hungary, India and Japan (see Meisenberg et al., 2017 and references therein).

Materials and Methods

Our group performed numerous assessments of surface sealing techniques both in an authentic mud house in northern Vietnam and using standard-sized artificial mud bricks in the laboratory in Hanoi using RAD7 and SARAD® RTM2200 instruments.

Results and Discussion

Thoron concentrations in excess of 1000 Bq m^{-3} were frequently encountered in room air close to mud walls of northern Vietnamese mud houses. Inhabitants often place their beds next to walls where thoron concentrations are much higher than in the center of the room. In contrast to thoron with its short half-life of ~55 seconds, the longer-lived ^{222}Rn with a half-life of ~3.8 days is rarely of concern in mud houses because their typically drafty construction allows for fast ventilation of room air. An inhaled atom of ^{222}Rn will likely be exhaled over the next day before it decays in a human body, whereas an inhaled atom of thoron that readily dissolved in the lung's fluid will almost certainly decay in the human body and contribute to radiation damage in tissue.

Neither the population nor governmental and public health authorities in Vietnam have been aware of the wide-spread thoron geohazard. Enhanced ventilation of rooms is unable to significantly decrease the concentration of thoron near mud walls. The literature provides no example of a feasible remediation strategy that fits the needs of developing countries. Barring expensive filtering approaches, the only promising strategy is to apply a diffusion barrier on inside walls and to delay the escape of ^{220}Rn until the short half-life of ~55 seconds has caused safe decay within the porous mud wall.

Abundant deep cracks in most mud walls prevent layers of paint to provide an adequate seal. Hung tapestry, sheets of paper, and foil pinned to walls was also found inadequate.

Conclusions

Indoor thoron levels of mud-houses were found to be much higher than the average ^{220}Rn concentration in the environment (10 Bq m^{-3}; UNSCEAR, 1993), whereas ^{222}Rn abundances were typically lower than the recommended WHO (2009) action level. Rare renovation efforts in historic houses sealed interior walls and unwittingly remediated the ^{220}Rn problem, but the high cost of drywall, plastering, wall paper and paint makes such approaches unaffordable for most inhabitants of mud houses.

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