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α-RADIATION FROM HOME BUILDING MATERIALS LIKELY AFFECTING HUMAN HEALTH IN NORTHERN VIETNAM

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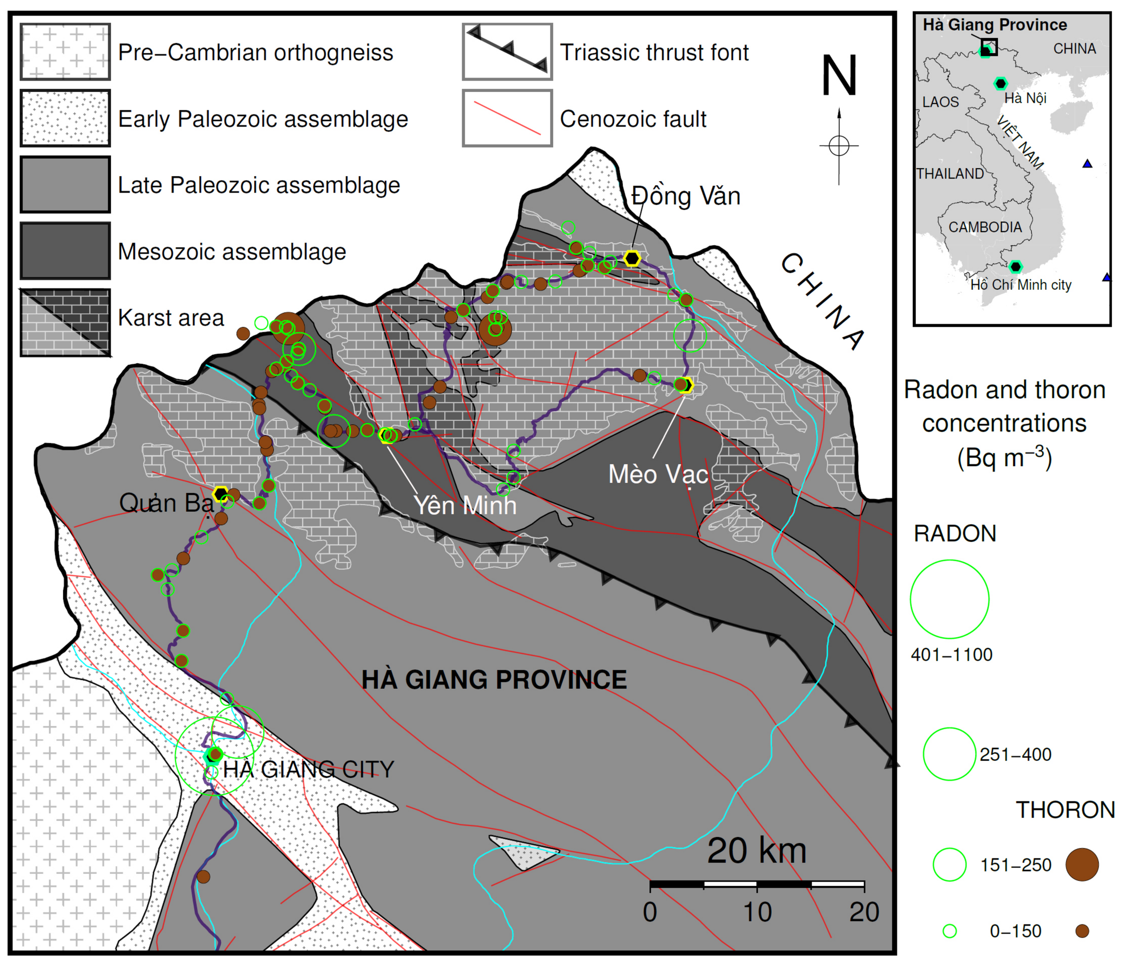
Introduction

Radon is a radioactive gas that is widely generated in rocks, soils, and building materials. It has been recognized as the second most important factor triggering lung cancer, after smoking as the leading cause. Depending on their geological origin and processing, building materials may contain enough thorium and uranium to significantly exhale radon isotopes into room air. The purposes of this survey are (i) to quantify the nuclide-specific α-radiation from ^{222}Rn (radon) and ^{220}Rn (thoron) in room air of common types of northern Vietnamese houses constructed with different materials, and (ii) to evaluate the total annual effective dose rate from indoor α-radiation for inhabitants of homes and to assess possible radiation-related health effects. Homes most susceptible to high α-radiation in indoor air are so-called 'mud houses' where bare walls and floors consist of compressed, dried soil.

Figure 1. Geological map of Đồng Văn karst plateau Geopark, a prominent mountainous area in northern Vietnam, with concentrations of radon and thoron in outside air, including air in large sinkholes.



In parts of northern Vietnam's mainly mountainous regions, the rural population often lives in houses built with local materials with bare inside walls and floors. Houses and farming activities are often located on rare flat land in the bottom of sinkholes and in valleys with limited wind and air exchange.

Radon isotope concentrations in ambient outside air

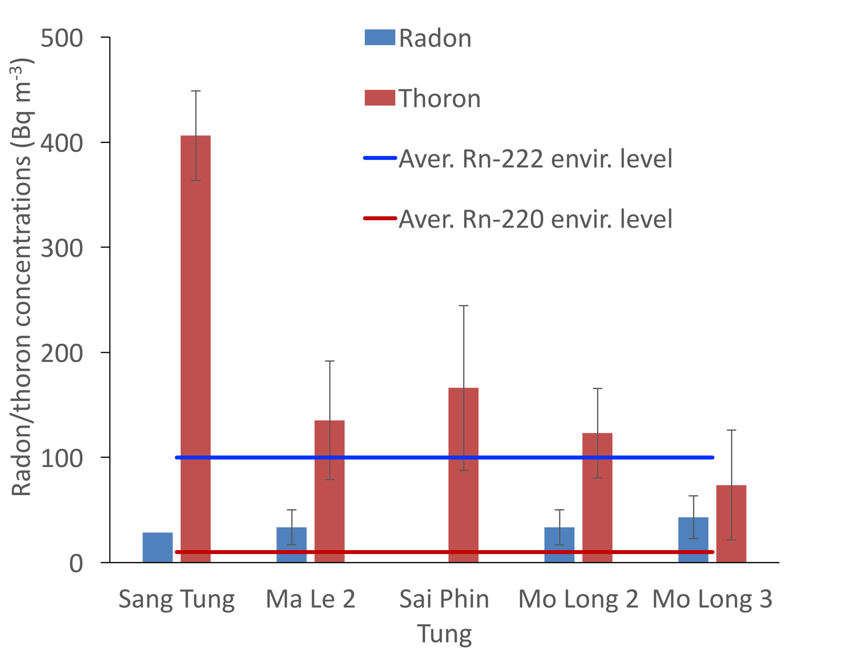


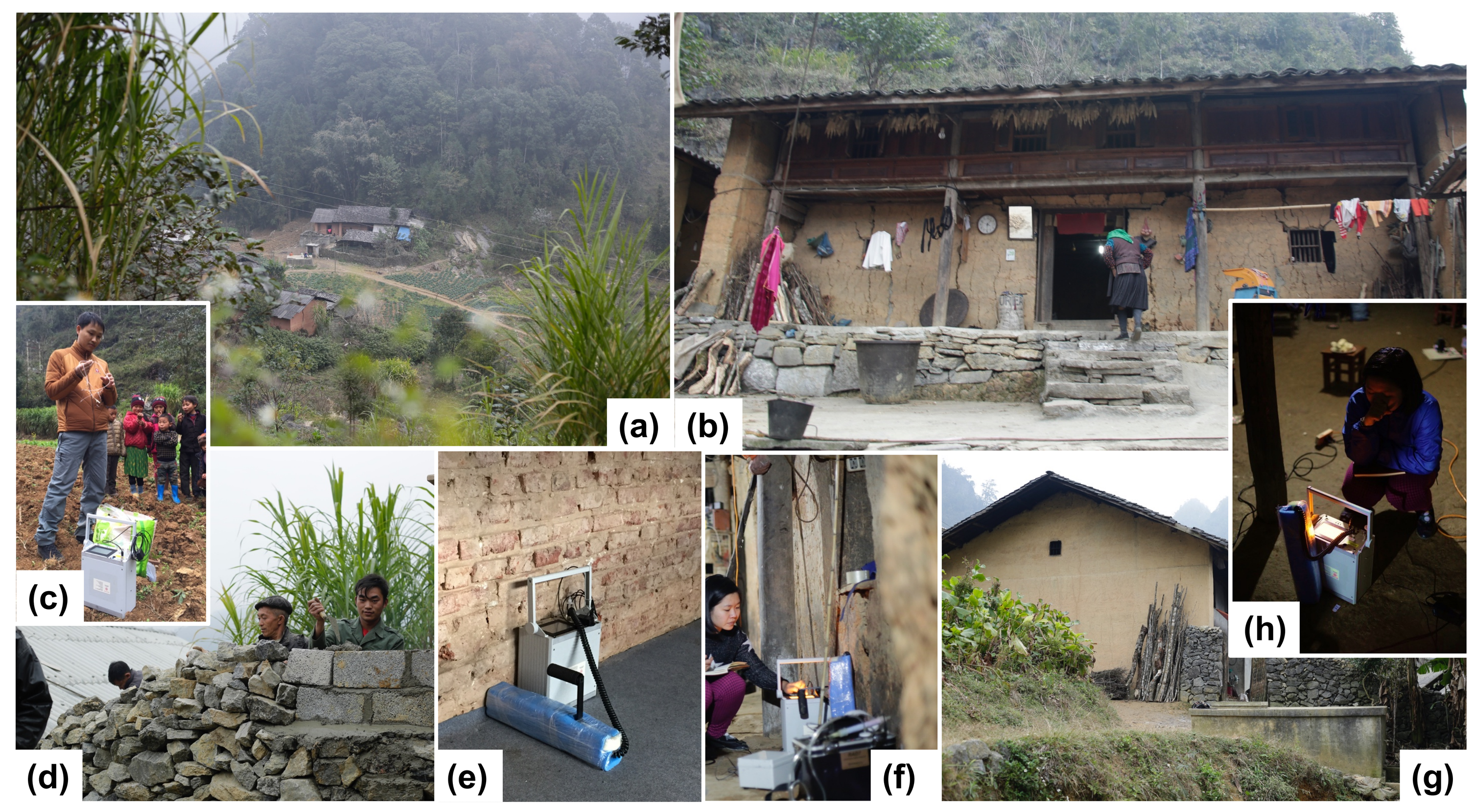
Figure 3. Radon and thoron concentrations in outside air at the bottom of sinkholes, where the rural population is farming and lives in houses (for comparison: according to UNSCEAR (2008), the average ^{222}Rn and ^{220}Rn levels in outside air are 100 Bq m^{-3} for radon and 10 Bq m^{-3} for thoron).

Concentrations of both radon and thoron were surveyed in outside air at the bottom of sinkholes with average values ranging from 29 to 43 Bq m^{-3} for radon, and from 74 to 406 Bq m^{-3} for thoron (Fig. 3). The abundances of ^{222}Rn are lower than the average environmental level of 100 Bq m^{-3} for radon, but ^{220}Rn levels are much higher than the average of 10 Bq m^{-3} cited in UNSCEAR (1993) for thoron in air. The clayey soil in sink holes, when used for home construction, is a significant source of thoron in room air.

Materials and methods

Surveyed homes were built with different materials, such as local soil (i.e. 'mud-house' building material), unfired-soil bricks, limestone, cement bricks from crushed limestone, and common fired-clay bricks. Measurements of both radon and thoron were performed with a SARAD® RTM2200 instrument in the air of different types of houses in the center of rooms and near walls (Fig. 2). Radon and thoron in air at the bottom of sinkholes were measured to identify radon and thoron concentrations in ambient air (Fig. 1).

Figure 2. Houses and farming areas are typically located in sinkholes **(a)**; a common traditional mud house in rural northern Vietnam **(b)**; survey of radon concentrations in the bottom of a sinkhole **(c)**, next to the fired-clay brick wall **(e)**, next to a mud wall **(f)**, and in the center of a mud house **(h)**; construction of a house wall with crushed-limestone bricks and limestone **(d)**; refurbished mud house **(g)**.



Radon concentrations in room air of different types of homes

The average total ^{222}Rn abundance in indoor air of all types of surveyed homes was < 100 Bq m^{-3}, but ^{220}Rn concentrations were far higher than ^{222}Rn and expressed a trend of increasing values from the center of rooms to locations closer to interior walls (Fig. 4). Thoron concentrations peaked close to walls of compacted and dried soil, unfired-clay bricks and cement bricks made from crushed limestone. A maximum thoron concentration of up to 1052 Bq m^{-3} was measured in air close to a wall of unfired-soil bricks. Thoron levels in the center of rooms without wall coverings (i.e. exposing raw building materials) typically exceeded 150 Bq m^{-3}. In contrast, thoron in the center of rooms was below the detection limit when walls were constructed with fired-clay bricks or concrete. Thoron measured around 86 Bq m^{-3} when compacted soil walls had been covered with a layer of plaster.

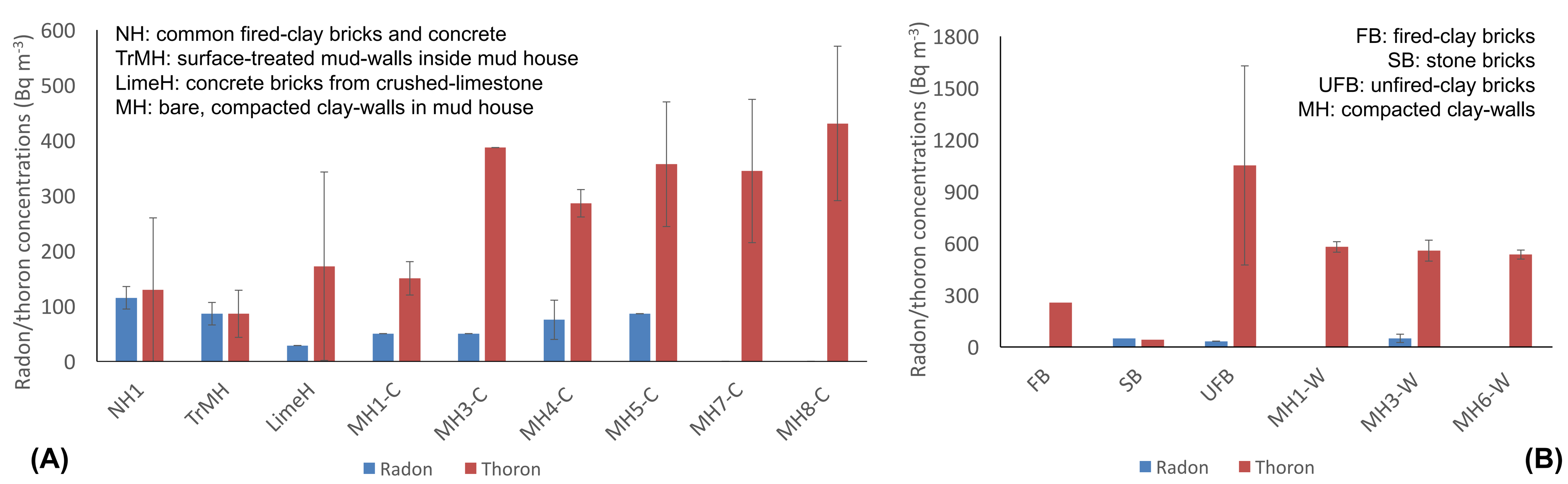


Figure 4. ^{222}Rn and ^{220}Rn levels in room air **(A)** in the center of rooms (left side) and **(B)** next to walls (right side).

Health risk due to lifetime exposure to radon at home

The average risk of developing lung cancer as a consequence of a lifetime exposure to indoor α-radiation in affected northern Vietnamese homes ranges from 3.9 % to 14.6 % (assuming 13 hours per day over 70 years of average life expectancy for inhabitants in Hà Giang province, according to 2009 to 2014 statistics by GSO, 2016). Thoron and its metallic progenies contribute more than 80 % of the total average lung cancer risk from both radon and thoron, being responsible for 2.7 % to 14.6 % of the risk of developing lung cancer. Practical mitigation strategies are needed to reduce indoor α-radiation from thoron and its metallic progeny in many traditional homes in northern Vietnam.

The total annual effective dose rates from radon and thoron and their progenies to inhabitants who spend about 13 h day^{-1} in the various types of houses in northern Vietnam are estimated to be higher than 6 mSv a^{-1} in houses where raw building materials are exposed, especially up to 37 mSv a^{-1} for place of bed in mud houses built with compacted soil (Nguyễn-Thuỳ et al., 2019). A range from 3.1 to 4.3 mSv a^{-1} is estimated for houses constructed with fired-clay bricks or where mud walls are covered with plaster (Fig. 5).

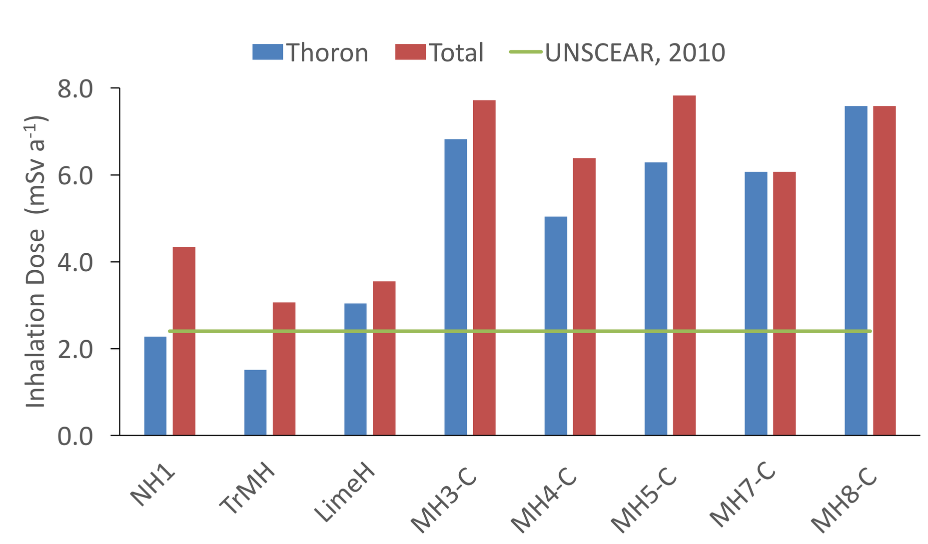


Figure 5. Average annual effective dose rates, estimated *via* average levels of radon and thoron in the center of rooms, for thoron only (blue bars) and for the total of radon and thoron (red bars). The recommended maximum annual dose rate is 2.4 mSv a^{-1} (red line; UNSCEAR, 2010).

References cited

- Nguyễn-Thuỳ, D., H. Nguyễn-Văn, J.P. Schimmelmann, N.T.Á. Nguyễn, K. Doiron and A. Schimmelmann, 2019. ^{220}Rn (thoron) geohazard in room air of earthen dwellings in Vietnam. *Geofluids, Vol. 2019, Article ID 7202616, 11 pages; DOI: 10.1155/2019/7202616*
- GSO, Ha Giang Statistics Office, 2016. Statistical Yearbook of Ha Giang 2015, 404 p., Ha Giang (in Vietnamese).
- The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 1993. Report to the General Assembly, with scientific annexes. United Nations sales publication E.94.IX.2. United Nations, New York.
- United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), "UNSCEAR 2008 Report to the General Assembly, with Scientific Annexes," in *Sources and Effects of Ionizing Radiation*, vol. I, United Nations, New York, 2010.

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