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# An approach to the subslab depressurization remedial action in a high $^{222}$Rn concentration dwelling

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ABSTRACT

Galicia (NW Spain) is a radon-prone area in the Iberian Peninsula. Measurements were carried out at a rural dwelling, with an annual average of radon concentration over 4000 Bq m$^{-3}$ and a maximum of 9000 Bq m$^{-3}$, found during a radon screening campaign held in the Autonomous Community of Galicia. We performed a detailed study to identify the main contamination source and the behaviour of the radon concentration, in which a linear dependence with temperature was verified, once corrected for relative humidity. We used different passive methods (charcoal canisters and two types of etched track detectors) as well as a radon concentration monitor that provided continuous measurement. Subsequent to this characterization, and in order to reduce the high radon concentration, a remedial action was developed using different passive and forced ventilation methods. A modified subslab depressurization technique was found to be the most effective remedy, providing a radon concentration reduction of around 96%. This method also has the advantages of being inexpensive and reliable over time.


## 1. Introduction

Galicia (in Northwest Spain) is geologically characterised by very old soils with an abundance of highly fractured mineral rocks rich in $^{238}$U. The province of Pontevedra (Fig. 1) was identified as a radon-prone area in the Marna Project (Quindós et al., 2004), a nationwide survey of natural gamma emission that reported exposure rates of 1–1.288 pC kg$^{-1}$ s$^{-1}$ (14–18 μR h$^{-1}$) (Fig. 2) in this area. By applying a theoretical model, the authors of that work related these outdoor gamma exposure values with indoor $^{222}$Rn concentrations ranging from 200 to 400 Bq m$^{-3}$.

Geological studies (IGME, 2009) of this area revealed a soil composition dominated by hercynian granite rocks, and, more precisely, migmatite granites with homogeneous granite areas. The superposition of the IGME information on the MARNA map shows a direct relation between the soil composition and the high gamma emission rate.

The LAR–USC (Laboratorio de Análisis de Radiaciones (LAR)–Universidade de Santiago de Compostela) is carrying out a systematic campaign to measure $^{222}$Rn in dwellings throughout Galicia. The dwelling under study, built in the 1960s, showed very high $^{222}$Rn concentrations, with mean values of 4800 Bq m$^{-3}$ and peaks close to 9000 Bq m$^{-3}$, far exceeding the action levels of 400 Bq m$^{-3}$ recommended by the E.U. for dwellings built before 1990 (The Council of the European Union, 1990, 1996). The house has been inhabited by the same family since its construction (Fig. 3 shows the plan of the house). It consists of a ground floor built on non-uniform land that had been refilled and leveled with blocks of leucocratic granite (calco-sodium) with medium grade biotites, built upon traditional, continuous ditch foundations (slab on grade) with no drain tiles or perforated pipes to direct water away. The structure is supported by key walls, and the floor is made of concrete and terrazzo laid directly over the filled land. Between the concrete ceiling and the roof there is a well-ventilated storage-room that is easily accessible by interior stairs. Insulation consists of cavity walls (outside walls) and double doors/windows with single-pane glass. These construction techniques were widely used for dwellings in this area in the 1960s–1970s.

There is an ancillary structure built on the same plot (10 m from the main house), with single walls, windows and doors, and a concrete-terrazzo floor laid directly over the filled land, as in the

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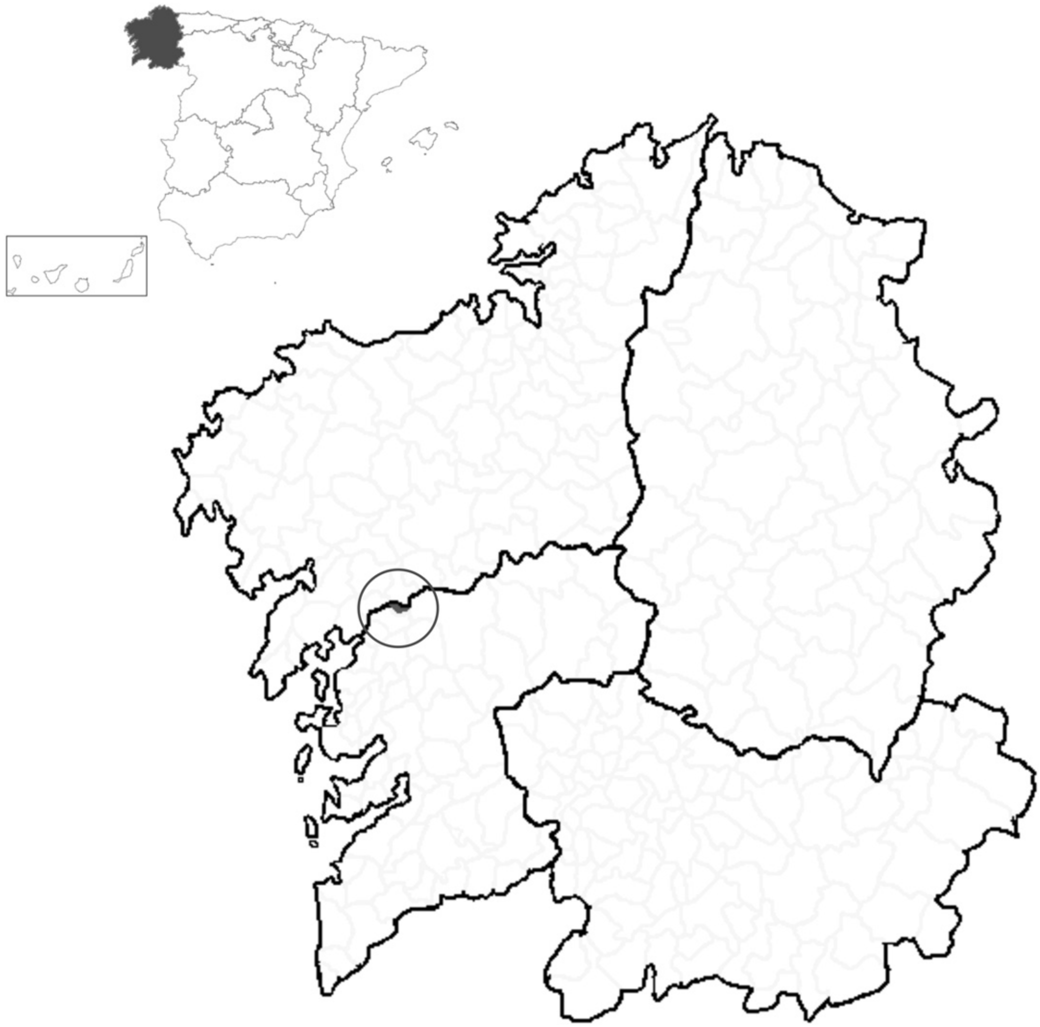

**Fig. 1.** Location of the dwelling under study (encircled) in relation to Galicia and Spain.

main house. This auxiliary structure has five highly ventilated rooms, two of which were used for control measurements in this study.

When a first measurement using charcoal canisters showed such high values, we performed a systematic and detailed study, paying particular attention to those places in the dwelling exhibiting the highest exhalation rates. The study combined the use of charcoal canisters and different etched track detectors in order to depict the problem, with a view to remedial action. A radon continuum monitor was also used to determine a possible correlation between atmospheric parameters and $^{222}Rn$ concentration during different phases of the study.

## 2. Measuring methods

Short exposure time measurements were carried out following a modified EPA 520/5-87-05 protocol (Gray and Windham, 1987), in which an HpGe detector (Ortec, model GMX-50) with digital electronics (Ortec, model DSPEC) was used instead of a NaI (Tl) scintillator. Air samples were collected using F&J active charcoal canisters, model RA40 V. Each charcoal canister was exposed for a period of 48 h. Once secular equilibrium between radon and its short-period daughters ($^{214}Pb$ and $^{214}Bi$) was reached, radon concentration was measured. The total activity in the sample, in the energy spectrum region between 295 keV and 609 keV, was then compared with the equivalent activity of a standard source. The average sample analysis time was 10 min.

Long exposure time measurements were also carried out using etched track detectors exposed for 90 days, typically. The detectors

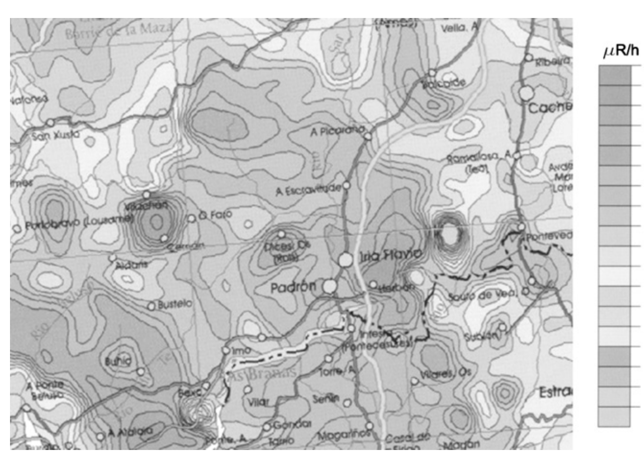


**Fig. 2.** Marna map of the area of interest.