



Survey on radon activity in the air of dwellings of Curitiba urban area and Carambeí rural region (Paraná State, Brazil).

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1. Introduction

Radon gas is recognized as an etiological agent of lung cancer, which is responsible for more than 50% of the exposure to natural radiation and is considered the second cause of lung cancer. Radon radionuclides are part of the natural radioactive series of uranium and thorium, which rather easily diffuse from soil, water, rocks, and construction materials into the atmosphere of dwellings. Indoor human exposure to natural radiation is mainly due to inhalation of radon. Radon undergoes decay through the emission of an alpha particle that can interact with human lung tissue causing damages [1, 2]. Preliminary studies performed in Brazil show that the concentration of radon in most cases is below the recommended levels, but in some places the radon activity level were found above 600 Bq/m³. Created more than 17 years ago, the Laboratory of Applied Nuclear Physics (LFNA), which belongs to the Federal University of Technology – Paraná (UTFPR), has been conducting systematic research concerning radon measurements in dwellings and working places of Paraná State regarding soil, water and building materials. The main objective of present research was focused on comparative measurements of ²²²Rn indoor concentration in the region of Carambeí rural region and Curitiba urban area (State of Paraná – Brazil).

2. Methodology

The region of Carambeí was defined using the data of gamma aeroradiometric geological studies performed by the Federal University of Paraná (UFPR) [3, 4], where high rates of uranium, thorium and potassium were detected. Field recognition and subsequent agreement with residents were carried out, where 40 detached houses in this rural area as well as 20 dwellings in Santa Felicidade region of Curitiba urban area were selected for the research. For indoor radon measurements were performed using diffusion chambers with polycarbonate detector (CR-39). Each dwelling and detached house was monitored using two passive detectors which were installed in the living room and bedroom, where families usually spend most of their time. Background measurements were performed using similar diffusion chambers installed in controlled Laboratory atmosphere with radon activity close to zero. The installation of the chambers was carried out following the procedures previously validated by the LFNA/UTFPR. Concomitant to the installation, the residents received necessary guidance to ensure adequate data collection. After the

exposition period of 90 days the CR-39 detectors were removed from dwellings and consequently were submitted to chemical etching using 6.25 M NaOH solution plus 2% of ethyl alcohol at a temperature of 72° C for 14 hours [5].

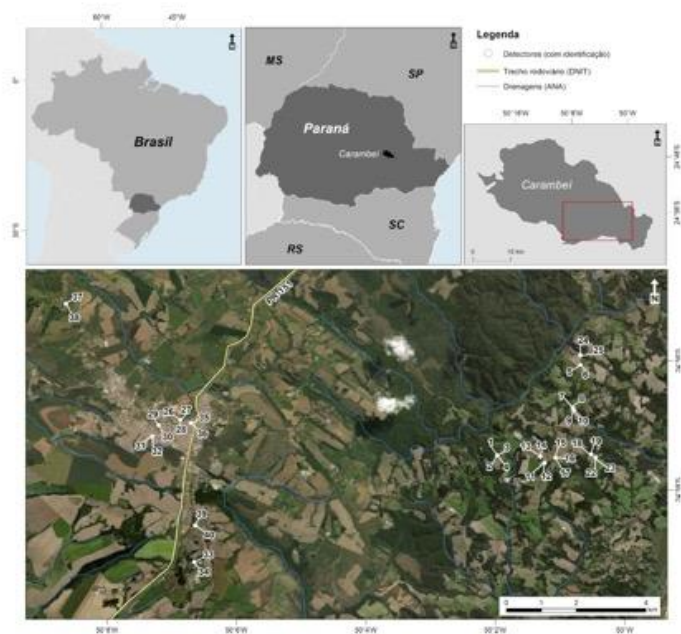


Figure 1: Identification of rural area of Carambeí region chosen for present survey.

The alpha particle tracks were manually counted using microscope with an optical magnification of 100x. The concentration of radon activity in the monitored atmosphere was calculated using the calibration factor obtained by the LFNA in 2011 and reassessed through periodic intercomparisons.

3. Results and Conclusions

Obtained results show that indoor concentration levels of ^{222}Rn in Carambeí rural region ranged from $95 \pm 15 \text{ Bq/m}^3$ to $461 \pm 65 \text{ Bq/m}^3$. In the case of detached house with high (above 300 Bq/m^3) radon activity levels, the mitigation measures were proposed to the proprietaries, which include better ventilation of studied room, floor cracks and basement joints sealing. It was expected to find elevated level of radon activity in the air of dwelling in the region with high levels of natural gamma radioactivity of uranium, thorium, radium, potassium, which was found in previous geological studies [3, 4]. The radon activity concentration measured in the dwellings of Santa Felicidade district in Curitiba - PR, presented values that ranged from $87 \pm 14 \text{ Bq/m}^3$ to $143 \pm 22 \text{ Bq/m}^3$, which are below the maximum recommended limit of 300 Bq/m^3 [2]. The results of present survey are in good agreement with other data collected at Paraná, São Paulo, Minas Gerais and Rio de Janeiro states [6-8].

It's possible to see that excluding mentioned above value of $461 \pm 65 \text{ Bq/m}^3$ for radon activity concentration, both sets of data are in fair agreement and average radon activity in the air of studied dwellings of Carambeí and Santa Felicidade regions is $117 \pm 18 \text{ Bq/m}^3$, which is below the recommended ICRP limit as well as the United States Environmental Protection Agency (EPA) reference for upper level of radon activity of 148 Bq/m^3 . But it has to be mentioned also that the World Health Organization (WHO)

established a national annual average residential radon concentration reference level of 100 Bq/m^3 , which could be exceeded to 300 Bq/m^3 under the prevailing country-specific conditions.

It's evident that further measurements are required at the rural region of Carambeí, which presented high levels of natural gamma radioactivity as well as more measurements are required at Curitiba urban area. Unfortunately, present research was interrupted by COVID pandemic restrictions, which impeded the access to houses and dwelling as well as obstructed the CR-39 detectors installation and withdraw.

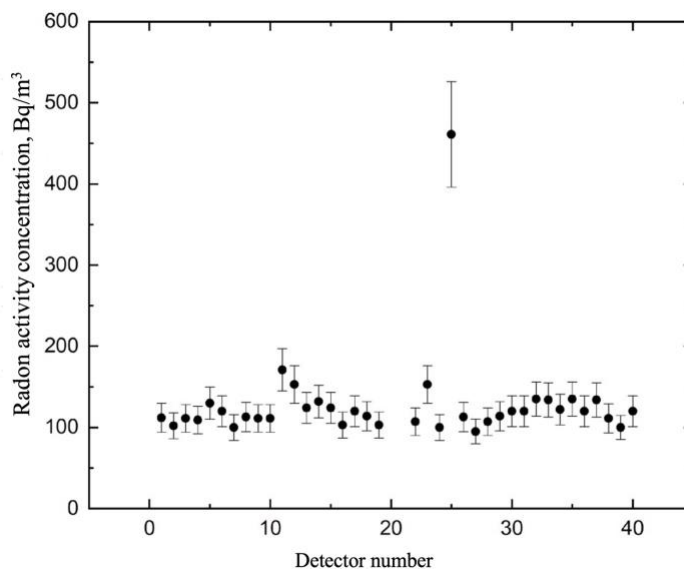


Figure 2: Obtained results of ^{222}Rn activity in the air of dwellings at Carambeí region of Paraná State.

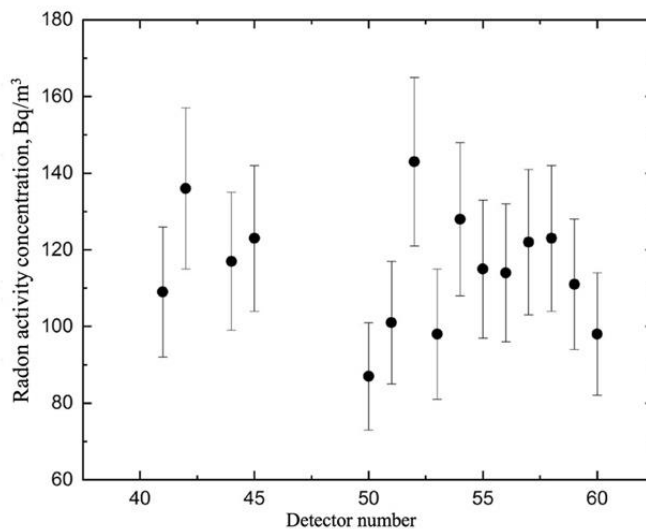


Figure 3: Obtained results of ^{222}Rn activity in the air of dwellings at Santa Felicidade region of Curitiba urban area.

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