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INDOOR RADON SURVEY IN TIRANA CITY, ALBANIA

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Abstract. *Indoor radon concentration is investigated in the urban area of Tirana city, the capital of Albania. CR-39 Solid State Nuclear Track Detectors (SSNTDs) are used to survey 147 dwellings and 78 workplaces during 3-month measurements. In dwellings, the arithmetic mean and geometric mean value of radon concentration are found to be 97 and 71 Bq/m^3, while in workplaces 131 and 98 Bq/m^3, respectively. Radon concentration on the ground floor in dwellings is higher than that of other floors, while for workplaces no significant difference is found among floors. Radon concentrations in dwellings and workplaces are found to be higher than the reference level of 300 Bq/m^3 for approximately 6% and 9% of cases, respectively. The results are spatially distributed using a grid of 1×1 km^2 realizing the indoor radon map showing the number of measurements and the arithmetic mean values. This information is used to assess the radiation health risk due to residential exposure to radon indoors.*

Keywords: *Tirana city, indoor radon, dwellings, workplaces, annual dose rate*

1. INTRODUCTION

Radon (^{222}Rn) is a radioactive gas that occurs naturally as part of the decay series of ^{238}U found in the Earth's crust, rocks, and most common construction materials [1,2]. Radon, an invisible, tasteless, and odorless gas, can accumulate in enclosed areas, especially those with poor ventilation and structural elements in contact with the ground, such as basements and ground floors [2-8]. Long-term exposure to elevated levels of radon in such areas can pose health hazards, which are recognized by the World Health Organization (WHO) and by multiple epidemiological studies that have established a robust and statistically significant data between radon exposure and lung cancer occurrence, even at levels previously considered safe [8].

In Albania, some initiatives have been undertaken to assess indoor radon levels [10-12]. The Albanian legislation addresses the concern of exposure to indoor radon in the Council of Ministers Decision (V.K.M. No. 957), following the recommendations of the European Union [13,14]. The average annual concentration of radon in the indoor environments of workplaces, residential buildings and public buildings should not exceed 300 Bq/m^3. Thus, monitoring the levels of indoor radon concentrations in residential buildings and workplaces is crucial for assessing population exposure and managing radiological risk at the national level.

This study carried out in Tirana, the capital of Albania, aims to assess radon concentration levels in dwellings and workplaces by using Solid State Nuclear Track Detectors (SSNTD). The research results show that radon concentrations on the ground floor of homes are higher than those on upper floors, while in workplaces, no significant differences are detected between the floors. These data are utilized to evaluate population exposure.

2. MATERIALS AND METHODS

Radon concentration measurements were conducted in the city of Tirana, where about a third of Albania's population lives. In Tirana, Albania, numerous studies have been carried out from 1999 to 2022 to evaluate indoor radon levels, involving 225 measurements. CR-39 SSNTDs are used long-term measurements and placed on different floors in 147 dwellings and 78 workplaces at a height of approximately 1 and 2 m in height from the floor and as far as possible from windows (when present) and doors to avoid air currents. The detectors were exposed at each site for approximately three months during the

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winter and spring seasons. The exposed detectors are chemically etched, a process that reveals the latent tracks produced by the alpha particles as radon decays, which are than observed through an optical microscope, as detailed in Tushe et al. (2016) [11].

3. Results and Discussion

The results obtained for indoor radon concentration levels in living room and bed room are shown in Figure 1. The data show a lognormal distribution confirmed using the Kolmogorov-Smirnov test, and the statistical analysis of each distribution is summarized in Table 1 [9,12,15].

Table 1. Statistical analysis of radon concentration (Bq/m3) in apartments/houses and workplaces/public buildings

Statistical analysis	workplaces/ public buildings	apartments/ houses
Minimum	22	19
Maximum	850	616
Median	95	57
Geometric mean (GM)	98	71
Arithmetic mean (AM)	131	97
Standard deviation (SD)	124	97
Skewness	3.3	2.6
Curtosi	14.9	7.9

The average indoor radon concentration in apartments/houses were found to vary from 19 to 616 Bq/m^3 with an arithmetic mean of 97 Bq/m^3 (geometric mean value 71 Bq/m^3), while in workplaces/public buildings from 22 to 850 Bq/m^3 with an arithmetic mean of 131 Bq/m^3 (geometric mean value 98 Bq/m^3). In Figure 2, the median radon concentration by floor level is presented for both dwellings and workplaces. Floor level "0" refers to the ground floor, while floor level "−1" refers to basements. Radon concentrations are highest in the basements of dwellings and decrease steadily with increasing floor level, while in workplaces, radon concentrations show little variation between floors. In apartments/houses approximately 70% of the results are found to be above 100 Bq/m^3, while in workplace/public building only approximately 50%. However, only 6% of the results are found to be above 300 Bq/m^3 in apartments/houses and 9% in workplaces/public buildings.

Tirana city covers a surface of 42 km^2 and has approx. 400 000 inhabitants, which distribution is shown in Figure 3 (top left). The distribution of the results between apartments/houses and workplaces/public buildings is shown in Figure 3 (top right). The results are spatially distributed using a grid of 1×1 km^2 realizing the indoor radon map showing the number of measurements and the arithmetic mean (Figure 3 bottom left), where is indicated also the number of measurements per cell. The arithmetic mean of radon concentration is shown in Figure 3 (bottom right), indicating the central area of the city showing concentration of radon above 100 Bq/m^3. These results are a valuable support for radon measurement planning and dose assessment of the population.

Although the survey was limited to Tirana city, the data can be considered representative for the capital area. Measurements were distributed across all main urban zones, ensuring coverage of both densely populated districts and different building types and floor levels. This mixed population-weighted and geographically based design provides adequate representativeness for urban exposure assessment

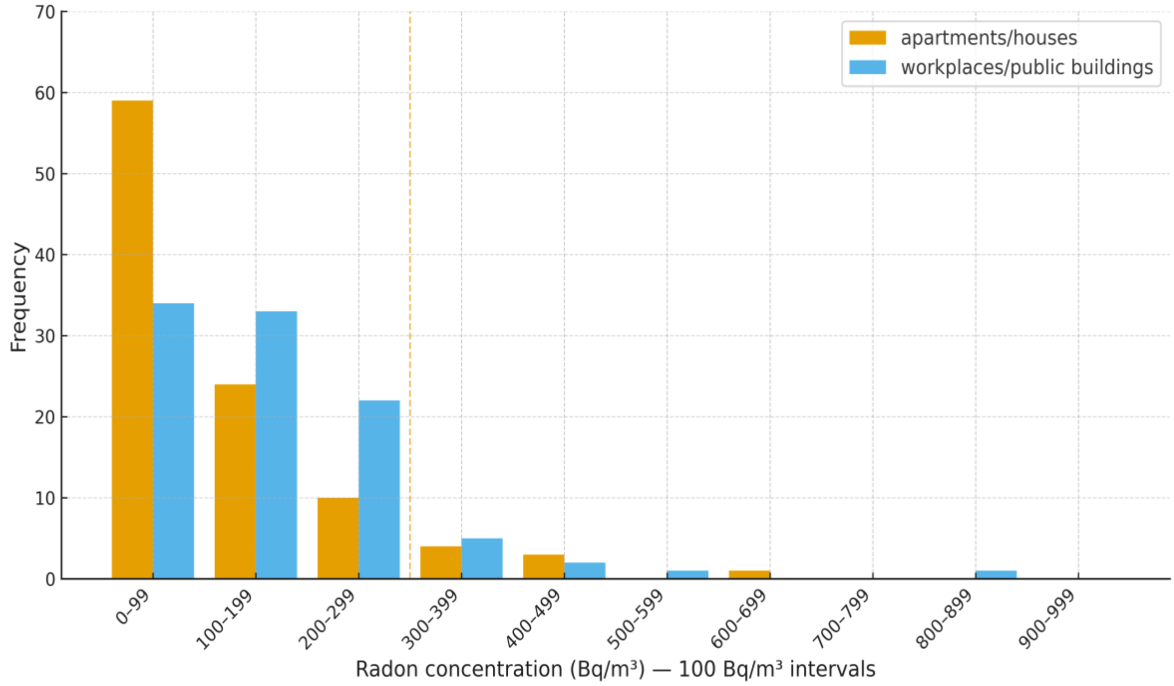

Figure 1. Frequency distribution of indoor radon concentration in apartments/houses and workplaces/public buildings

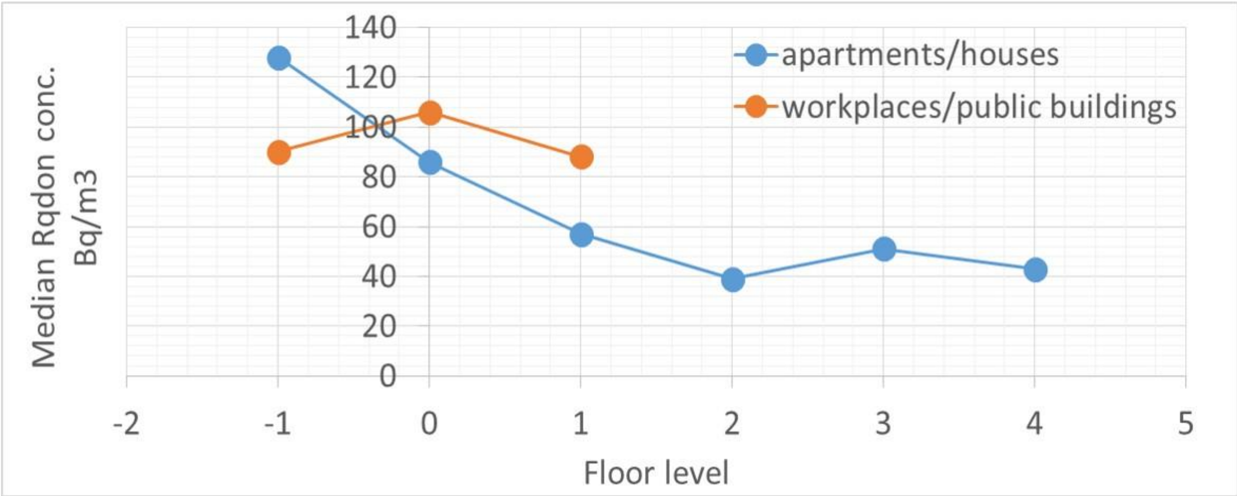

Figure 2. Median radon concentration by floor level in apartments/houses and workplaces/public buildings.

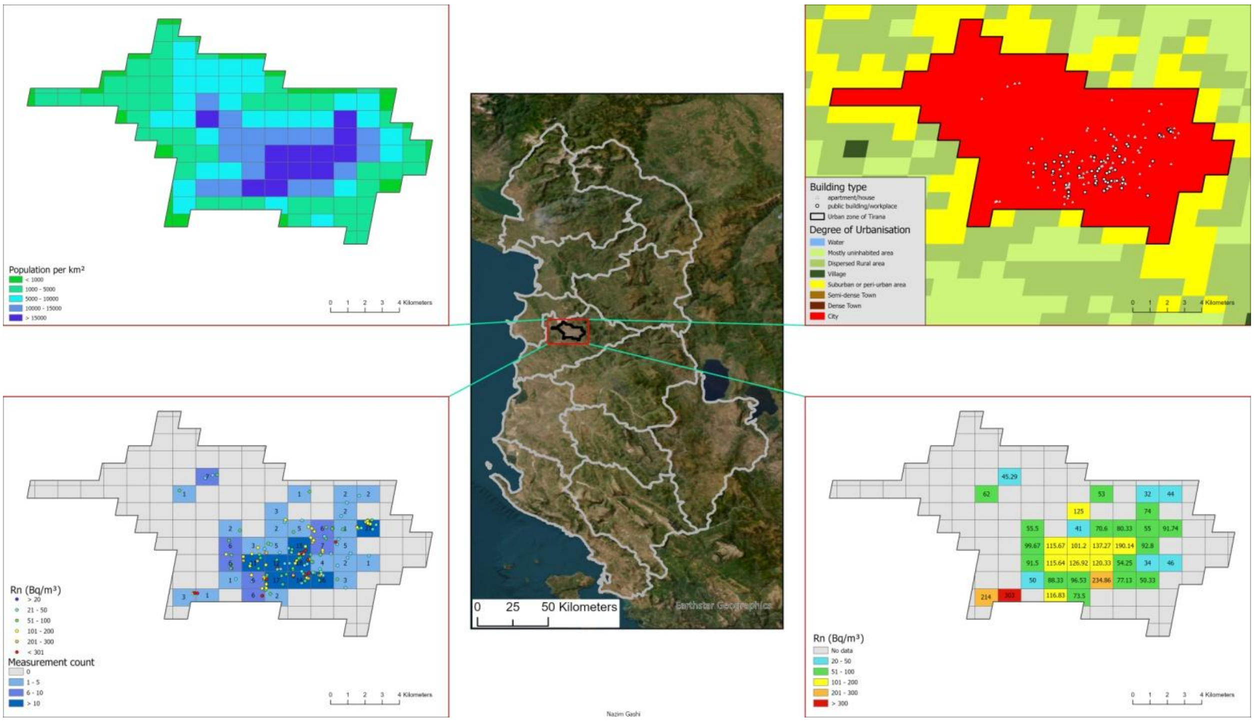

Figure 3. The ratios of radon concentrations between both bed rooms/living rooms in houses and apartments

The annual effective dose due to exposure to radon gas in the dwellings and workplaces has been estimated based on the recommendations of the European Commission 2024/440 of 2 February 2024, which aim to unify the calculation method and specifically the selection of dose coefficients. ICRP Publication 137 recommends a dose coefficient of 3 mSv per mJ/hm³ (approximately 10 mSv per working level month) for most circumstances of exposure in workplaces, equivalent to 6.7 nSv per Bq h/m³ using an equilibrium factor of 0.4.

$$E\ (mSv/y) = C_{Rn} \times t \times DCF \qquad (1)$$

where C_{Rn} is radon concentration, t is occupancy time 2000 hr (workplaces) and 7000 hours (indoor), DCF is dose conversion factor [16-18].

Based on the arithmetic mean concentrations, the annual effective dose was estimated to be 4.6 mSv/y for public members (dwellings) and 1.8 mSv/y for workers (workplaces/public buildings). These values better reflect collective exposure and are consistent with UNSCEAR recommendations.

4. Conclusion

Indoor radon concentration levels in Tirana city are measured in 147 apartments/houses and 78 workplaces/public buildings in different floors. However, radon concentration on the ground floor in dwellings is higher than that of other floors, while for workplaces no significant difference is found among floors. From the analysis of these results, we found that respectively 6% and 9% of the results in apartments/houses and workplace/public buildings are above the reference level of 300 Bq/m³. The arithmetic mean–based value of the annual effective dose rate was estimated to be 4.6 mSv/y for public members and 1.8 mSv/y for workers. These findings should be interpreted with caution since the dataset, although valuable for Tirana city, is not fully representative for the whole country.

The results are spatially distributed using a grid of 1×1 km² showing the number of measurements and the arithmetic mean of indoor radon concentrations.

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