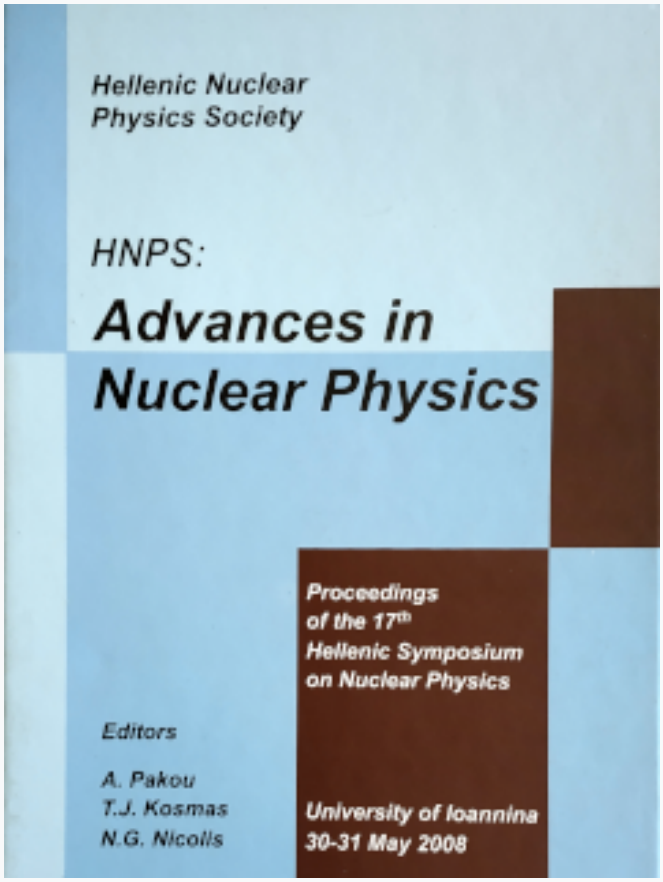
ePublishing

ΕΘΝΙΚΟ ΚΕΝΤΡΟ ΤΕΚΜΗΡΙΩΣΗΣ
NATIONAL DOCUMENTATION CENTRE

Annual Symposium of the Hellenic Nuclear Physics Society

Τόμ. 16 (2008)

HNPS2008



Occupational and residential radon exposure: a study in North-Western Greece

D. L. Patiris, K. G. Ioannides, C. A. Papachristodoulou

doi: 10.12681/hnps.2574

Βιβλιογραφική αναφορά:

Patiris, D. L., Ioannides, K. G., & Papachristodoulou, C. A. (2020). Occupational and residential radon exposure: a study in North-Western Greece. *Annual Symposium of the Hellenic Nuclear Physics Society*, *16*, 190–194. https://doi.org/10.12681/hnps.2574

Occupational and residential radon exposure: a study in North-Western Greece

D. Patiris, K. Ioannides, C. Papachristodoulou

Department of Physics, The University of Ioannina, 45110 Ioannina, Greece

Abstract

Measurements of indoor radon concentrations were performed in 44 workplaces and 87 dwellings in the region of Epirus, north-western Greece, using electret and alpha-track detectors. Radon concentrations followed a log-normal distribution with an arithmetic mean of 92 Bq/m^3 in workplaces and 86 Bq/m^3 in dwellings. A mean annual effective dose of 0.64 and 1.63 mSv/y was estimated for occupational and residential exposure, respectively. The reported data contribute to the assessment of radon distribution and dose estimate at the national level.

1 Introduction

Radon and its decay products are significant natural sources of radiation exposure for the general population, both in the living and working environment. Thus, over the last decades, surveys of indoor radon are continuously performed worldwide. In Greece, a national indoor radon mapping is still lacking, although several small-scale studies in dwellings have been published. The more comprehensive survey has been carried out from 1995 to 1998, including data from more than 1000 dwellings, mainly located in the eastern and southern country [1]. A recent pilot study reported radon concentrations in 561 workplaces in 19 prefectures covering north-eastern Greece [2].

In this work, radon measurements were performed in typical workplaces and dwellings in Ioannina, which is a major city with a municipal population of approximately 75,000 (2001 census), located in the region of Epirus, north-western Greece. The area has not been included in large-scale surveys of indoor radon and only fragmentary data appear in literature (see Fig. 1). The reported results aim at contributing to the assessment of radon distribution and dose estimate at the national level.

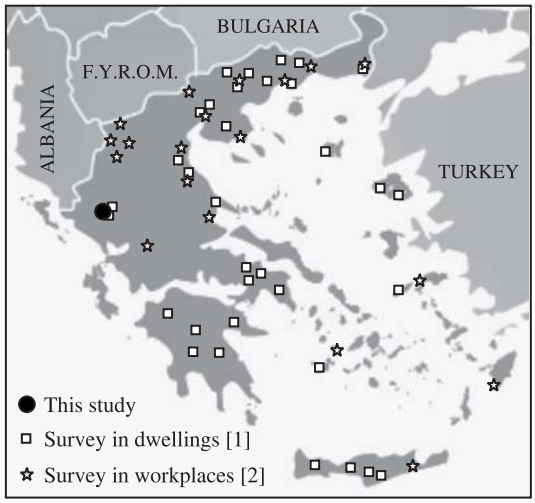


Fig. 1. A map showing the sampling location of the present study. The area has scarcely been included in previous investigations of indoor radon.

2 Materials and Methods

Electret Ionization Chambers of the "H"-type (E-PERM, Rad Elec Inc., USA) were used for passive radon measurements in 44 public workplaces, situated in the University, the University Hospital and the Ioannina Prefecture Administration buildings. In all workplaces, the E-PERM chambers were installed during both summer (May-July) and winter (November-January) periods and exposed for 8-10 days.

Radon measurements were performed during summer (May-September) and winter (October-April), in 87 randomly selected dwellings in the area of Ioannina, using CR-39 solid state nuclear track detectors (Pershore Moulding Ltd., UK). The experimental setup, etching protocol, track counting and calibration procedures have been described elsewhere [3,4].

3 Results

3.1 Radon concentrations

Radon concentrations in workplaces follow a log-normal distribution (p¡0.05), as shown in Fig. 2a. The results fall within the range reported in a recent pilot study carried out in 561 workplaces in other parts of the country [2]. All

radon concentration values were found to be below 400 Bq/m^3, which is the action level implemented for workplaces by the Greek Radiation Protection Regulations, following the EC recommendation [5].

Summer and winter measurements were compared through a paired student's t-test and no statistically significant seasonal variation was established (p=0.298). However, one-way analysis of variance (ANOVA) followed by Fisher's LSD post hoc test, showed that radon concentrations measured in basement and ground floor workplaces were significantly higher than those measured in the first and upper floors (see Fig. 2b).

Radon concentrations in dwellings are log-normally distributed and range between 11 and 286 Bq/m^3 with an arithmetic mean of 92 Bq/m^3 (see Fig. 3a). All values were below 400 Bq/m^3 and only in two basement dwellings did values exceed 200 Bq/m^3, which are the action levels applying to existing buildings and future constructions, respectively [8].

No statistically significant variations were found between summer and winter radon levels and between radon levels measured in detached house and apartment dwellings. A significant variation with floor level was established, with mean radon concentrations decreasing from basement to upper floors (see Fig. 3b).

Previous measurements from 18 dwellings in Ioannina [1], yielded radon concentrations ranging from 26 to 600 Bq/m^3 with an arithmetic mean of 89 Bq/m^3. An older investigation [9] conducted in 55 dwellings in the town of Metsovo, situated in Ioannina prefecture, revealed higher radon concentrations ranging from 18 to 750 Bq/m^3 with an arithmetic mean of 170 Bq/m^3.

3.2 Dose estimates

The annual mean effective dose H (mSv/y) from radon and its decay products was calculated according to UNSCEAR [6], through the equation:

H = CxExFxTxD,

where C is radon concentration (Bq/m^3), E is the equilibrium factor between radon and its decay products (=0.4; [7]), F is the occupancy factor, T = 8760 h/y and D is the dose conversion factor (9x10-6 mSv per Bq/m^3; [7]).

Using the mean value of 92 Bq/m^3 for radon concentration in workplaces and assuming an occupancy factor of 0.22 (i.e. working for 1920 h per y), the annual mean effective dose was estimated to be 0.64 mSv/y. Those working in offices located on basement and ground floors attain the higher risk. It should

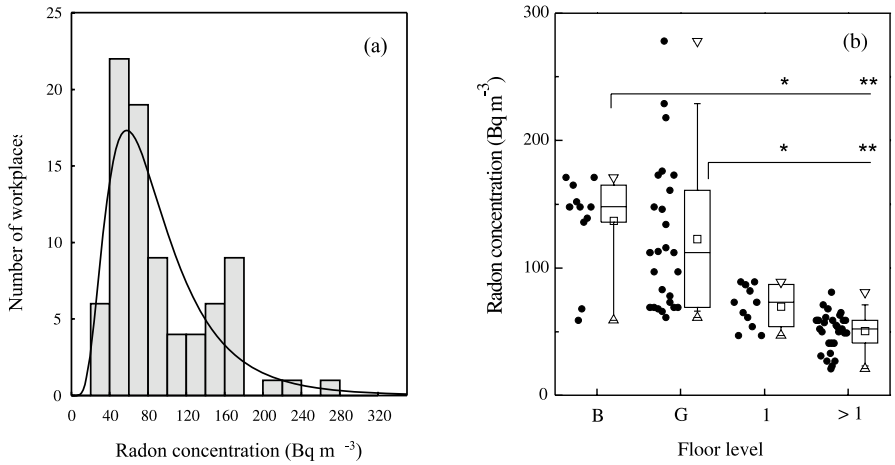


Fig. 2. (a) Distribution of radon concentrations measured in workplaces. (b) Box-whisker plot of radon concentrations, broken down by floor level (B=basement, G=ground floor, 1=first floor, ¿1=above first floor). Boxes represent the lower-upper quartiles and median values, whiskers denote the 5-95% range of the distribution and open squares stand for mean values. Statistically significant differences (* p¡0.001; ** p¡0.0001) between floors are also indicated

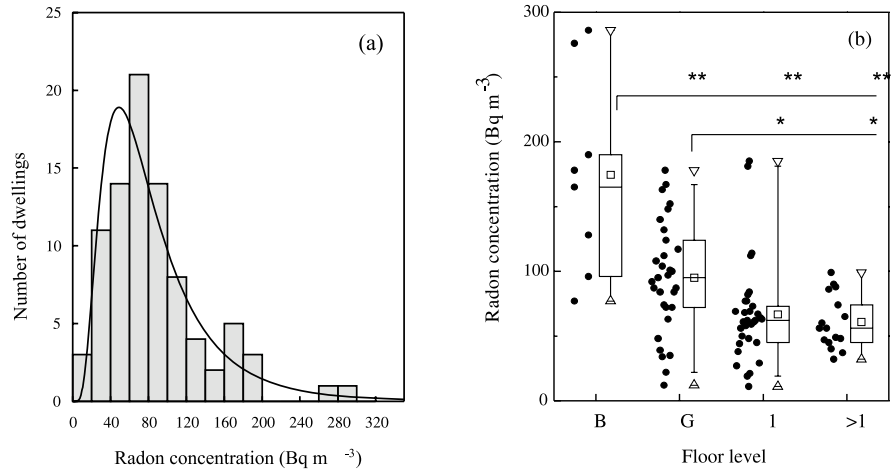


Fig. 3. (a) Distribution of radon concentrations measured in dwellings. (b) Box-whisker plot of radon concentrations, broken down by floor level (refer to Fig. 2b for symbol explanation).

be noted that these estimates are based on short term measurements that may not accurately reflect radon levels throughout the year.

The annual mean effective dose from residential radon exposure was estimated to be 1.63 mSv/y, assuming an occupancy factor of 0.6. This value is close to the worldwide average of 1.15 mSv/y reported by UNSCEAR [6] for the dose due to inhalation of radon decay products. On a national basis, annual effective doses between 0.09 and 28 mSv/y have been determined [1].

References

[1] D. Nikolopoulos, A. Louizi, V. Koukouliou, A. Serefoglou, E. Georgiou, K. Ntalles, Ch. Proukakis, J Environ Radioact 63(2002)173.

[2] A. Clouvas, S. Xanthos, M. Antonopoulos-Domis, Radiat Prot Dosimetry 124(2007)68.

[3] C.A. Papachristodoulou, K.G. Ioannides, K.C. Stamoulis, D.L. Patiris, S.B. Pavlides, Health Phys 862004)619.

[4] D.L. Patiris, K. Blekas, K.G. Ioannides, Nucl Instrum Meth B 244(2006)392.

[5] EC (European Commission), Radiation Protection Series 88 (European Commission, Luxembourg, 1997)

[6] UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation), Sources and effects of ionizing radiation. Report to General Assembly, with Scientific Annexes (United Nations, New York, 2000).

[7] ICRP (International Commission on Radiological Protection), Protection against Radon-222 at home and at work, ICRP Publication 65 (Pergamon Press, Oxford, 1994).

[8] EC (European Commission), 90/143/Euroatom (Commission of the European Communities, Brussels, 1990)

[9] K. G. Ioannides, K. C. Stamoulis, C. A. Papachristodoulou, Health Phys 79(2000)697.