INFLUENCE OF THERMAL COMFORT AND BUILDING MATERIALS ON INDOOR RADON AIR CONCENTRATION IN SOME REGIONS FROM TRANSYLVANIA (ROMANIA)

C.Cosma[1], D.Ristoiu[1], G.Sandor[2], T.Jurcut[3], S.Ramboiu[4], A.Poffijn[5]

[1] University "Babes-Bolyai", Department of Physics, 3400 Cluj Napoca, Romania
[2] Research Laboratory for Radiological Protection and Ecology, 3638 Stei, Romania
[3] University of Oradea, Department of Science, 2700 Oradea, Romania
[4] Medical Center for Health Services and Management, 3400 Cluj Napoca, Romania
[5] University of Gent, Nuclear Physics Laboratory, 9000 Gent, Belgium

ABSTRACT

The purpose of this work is to see the influence of the heat preservation in the cold season and also to show the building material influence on the indoor radon concentration in dwellings. Three methods were used to measure the radon content in houses and buildings (workplaces). The results of measurements show that in the winter season the indoor radon concentration is about 2 times higher than in the summer season for these regions from Transylvania. This fact is due that in the cold season there is an evident tendency to preserve the heat, that is, the natural ventilation is very feebly. The influence of building materials on indoor radon concentration is clear shown in the fourth region namely Stei which is a region in the neighborhood of an uranium mine and in some of these houses uranium wastes were used as building materials.

KEYWORDS

radon concentration, ventilation, building material, heat economy, integrating measurement, lognormal distribution.

INTRODUCTION

Radon sources are the main natural sources of population irradiation (about 50%). In some regions this percentage can increase even to 80-90% as in Cornwall (England) region [1]. Because, between the indoor radon exposure and the lung cancer risk seems to be a direct relation [2] the knowledge of the radon concentrations in buildings is a very important parameter characterizing the indoor air quality.

The assessment of lung cancer risk due to radon exposure for general public is based upon the research of epidemiological studies made on uranium miners [3,4]. The main difficulty in this estimation consists in the fact that uranium miners are exposed, besides to radon and radon progeny, also to the external doses and especially to the radioactive dust with uranium particles which can fasten on the bronchial tubes [5].

To find this parameter the epidemiological studies made on general public must be very carefully designed in order to obtain significant results since the effect is masked enough by other factors as smoking, chemical pollutants, stress, individual resistance and uncertainties in radon exposure assessment [6]. The last specified factor can be minimized by measuring of indoor radon concentrations for large time period (one year) and in the case when these measurements are shorter (3 months or 6 months) a correction or an adequate choice of time measurement interval is necessary. Sometimes these uncertainties can be found by retrospective radon measurements [7,8]. It is possible that incorrect estimation to the indoor radon exposure to be the reason for which the results of some performed epidemiological studies are inconclusive [9-11].

Romania is a country from Central Europe (237.000 km^2) having a continental climate, with +21°C in July and –6°C in January as average temperatures. Transylvania as northwestern part of Romania presents moreover a cold season prolonged. In the last years we made about 400 integrating measurements for indoor radon in houses in the frame of an epidemiological study in two districts of Transylvania [12] and with occasion was observed the influence of thermal comfort and building materials on the results of the indoor radon concentrations. Also, some measurements using Lucas cells method and especially the continuos monitoring with Radim device made in the last year confirm this influence.

EXPERIMENTAL METHOD

The integrating measurements were made using the Karlsruhe radon diffusion chamber with makrofol electrochemically etched track detectors. The makrofol detectors were exposed for three months period in the cold season (June-August) both for detached houses and flats in the blocks of flats. Also, some workplaces in public buildings were considered. The etching and reading of the detectors were made at the Nuclear Physics Laboratory of Gent.

The Lucas cells grab samples method utilizes the scintillation flasks of 500 ml and to standardize the measuring conditions all determinations were made after five hours of closing rooms. The calibration of Lucas cells was made using a radium chloride standard source.

Starting from this year we made continuos measurements of indoor radon by means of a Radim monitor (Czech Republic) which utilize a radon diffusion chamber where the alpha emission of RaA(^{218}Po) is measured with a Si detector. The minimum activity for an hour of sampling is 30 Bq/m^3 with statistical error of ±20%. The memory of this device allows the continuos monitoring of radon content for long time.

RESULTS AND DISSCUTION

In Figure 1 are shown the results for radon concentrations in the case of 18 dwellings and work places from Herculane city obtained by integrating measurements in the winter season (December-February) and in the summer season (June-August). The detectors were always settled in bedroom at the ground floor for exactly 3 months period in the case of the dwellings and in four offices of public buildings also at ground floor. One can see that with two exceptions the winter radon concentration is much greater as summer concentration. The first exception is remarked for No.1 sample, which is a hotel office where the same natural ventilation exists in the winter as in the summer. The sample No.11 is a bedroom with a poor ventilation also in the summer due to unutilization or a short time utilization in that year (1995).

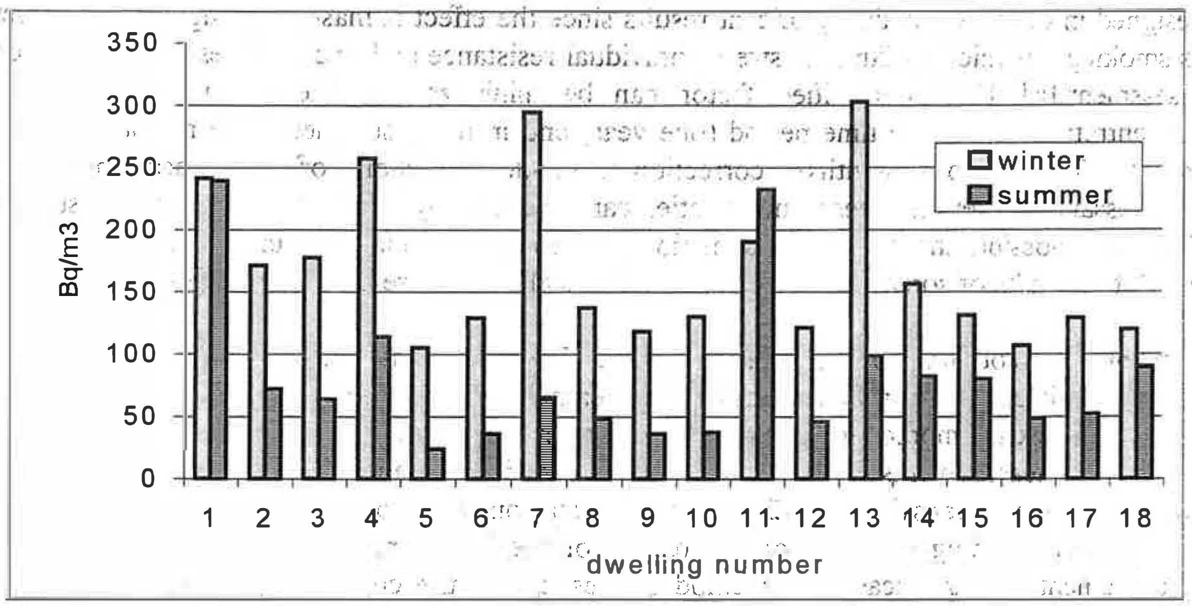

Figure 1: The radon concentration in winter and summer (14 bedrooms and 4 offices) from Herculane area

The winter/summer ratio for radon concentration (as average values) is shown in the last column of Table 1 and it can see that this ratio is about 2:1 for bedrooms in detached houses also for offices in public institutions and even 3:1 for bedrooms in blocks of flats at ground floor.

TABLE 1.

Seasonal variation of radon at ground floor (Bq/m^3)
Herculane (H) and Cluj (C) cities.

Type of building	Number of samples	Radon average concentration Bq/m^3		Ratio
		Winter	Summer	
Detached houses (H)	10	216	106	2:1
Flats block (H)	4	123	42.5	3:1
Offices (public) (H)	4	240	124	2:1
Cluj detached houses (C)	6	162	91	1.8:1
Cluj flats* (C)	4	115	55	2.2:1

*upper level (>2)

In the last two lines of Table 1 about the same ratio (1.8:1) was obtained for six bedrooms at ground floor from city Cluj in detached houses and (2.2:1) ratio for bedrooms in block of flats at upper level (>2).

In Figure 2 it is shown the daily variation of indoor radon in one house from Oradea city (bedroom in detached house) in January (1998) and in June (1998) registered with Radim device. The value of June is about 2.4 times smaller as January value. From this figure it is clear that an important variation of radon content exists during 24 hours due to accumulation of this gas in the night period. The computer program of this monitor directly indicates the mean values.

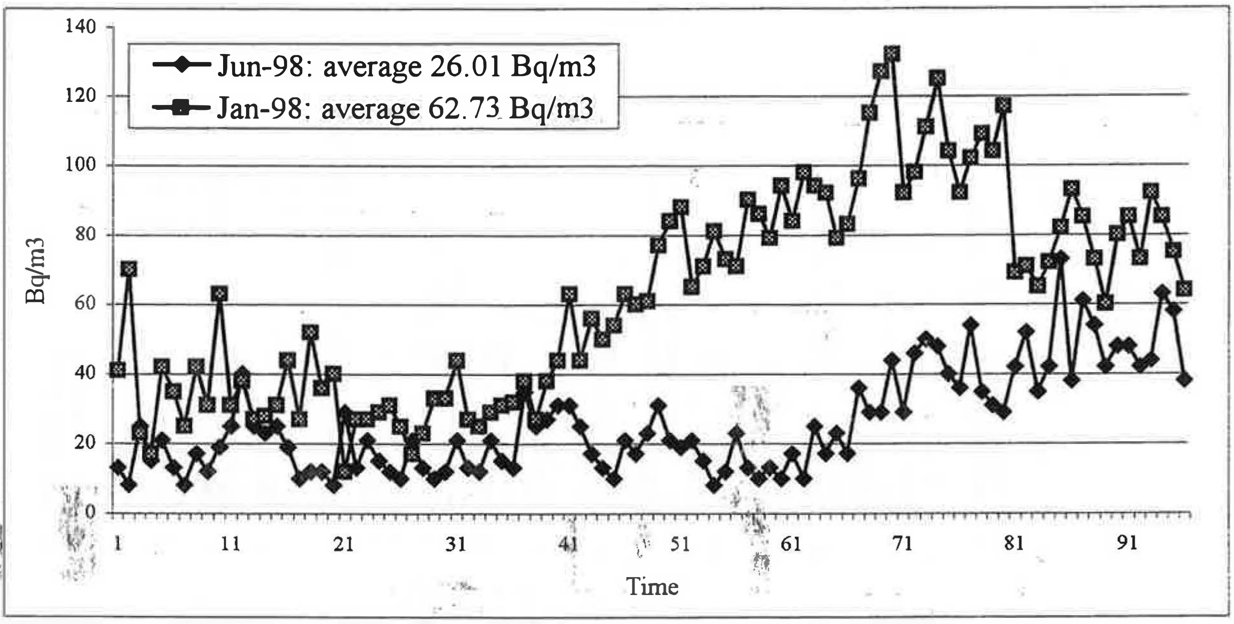

Figure 2. Daily variation (Radim monitor) and averages of radon content in one house from Oradea city (24 hours of measurement).

The grab samples method (Lucas cells) not confirm entirely these results being inadequately to establish this ratio because it apply the same protocol (0.5 h-strong ventilation following 5h-of room closing) to may standardize these determinations. Therefore, the adequately methods (integrating or continuos) for radon content determination in dwellings show that a ratio of 1.5 to 3 between winter/summer values exists for the all three regions investigated (Herculane, Cluj, Oradea). It is clear that tendency to preserve the heat during winter season can explain these ratios. Generally the cost for monthly heating in the cold season for a normal detached house is about 10-15% from the monthly amount gained by a standard family.

In addition, further two mechanisms can contribute of this growth of indoor radon during cold time. These are: (a) the chimney effect which contributes to the radon extraction from sublab of dwelling; (b) the soil frost during winter which can conduct the diffusive or connective soil flux towards house sublab.

The influence of building material was considered in this work by including in our study an uranium region. This is Stei city and its neighborhood. Stei city is placed at 15 km from an uranium mine (Baita) intensively worked in the 1950-1960 period. The results obtained by integrating radon measurement of three months for 80 dwellings of Stei area are shown in lognormal distribution in Figure 3. In this figure can be seen that this curve with two maxim presents high (234 Bq/m^3 and 269 Bq/m^3) and very high(1070 Bq/m^3 and 1231 Bq/m^3) values both for geometric mean (GM) and arithmetic mean (AM).

These results can be compared with the results obtained for 105 dwellings in different places from Cluj and Bihor districts (Transylvania) shown in Figure 4. representing about the first quarter of the results which will be gathered in the frame of an epidemiological study regarding the lung cancer risk. The geometric mean of 132.14 Bq/m^3 for these measurements is very closed to median value of 134 Bq/m^3, therefore, a classical lognormal distribution was found. The difference between the dwelling radon from Stei area and the other regions from Transylvania is rather high (234 Bq/m^3 for GM in Stei area comparatively with 132 Bq/m^3 as GM for the other

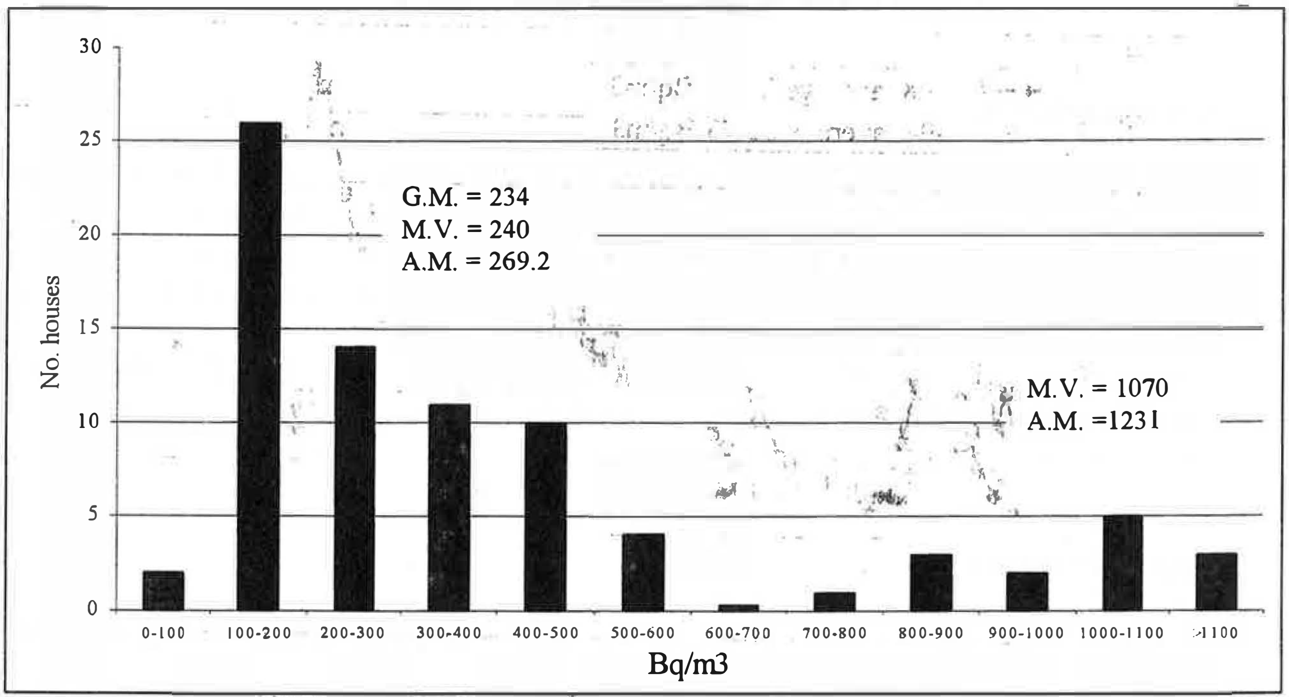

Fig.3. Distribution with two maxim for radon concentration in Stei area.

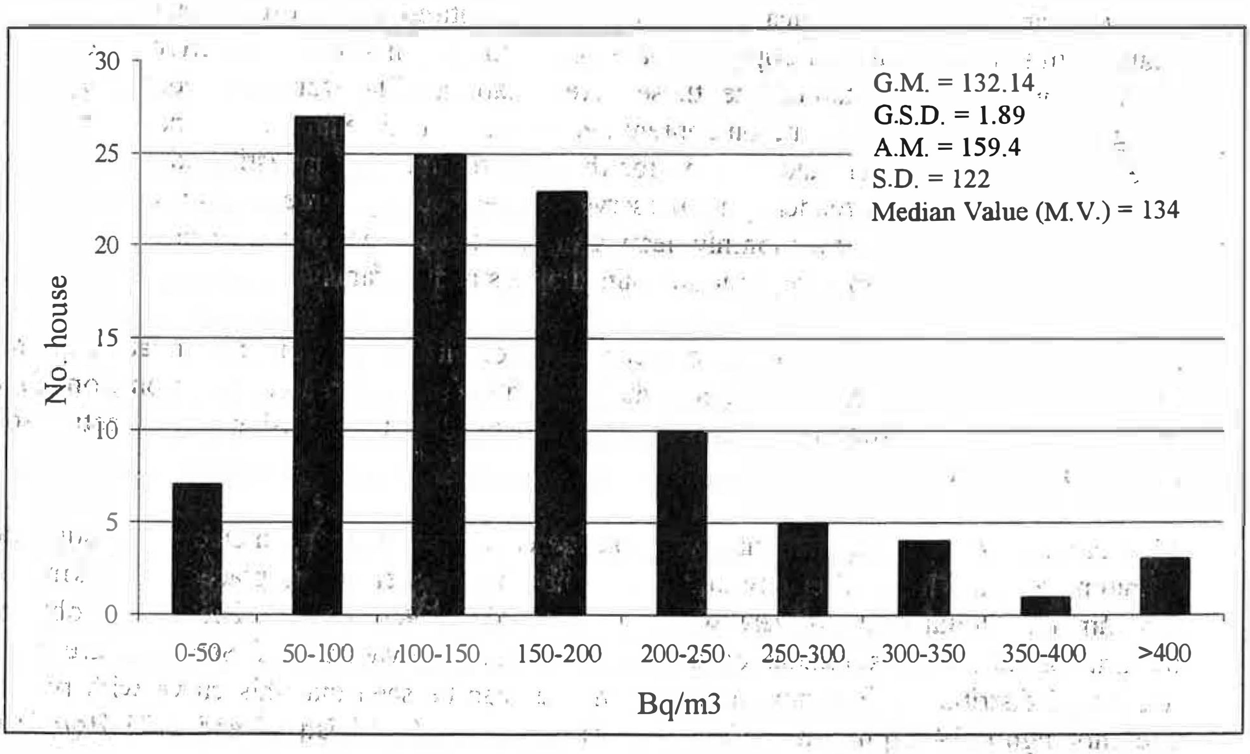

Fig.4. Lognormal distribution for radon in 105 dwellings from Transylvania region.

regions) and can be attributed to building materials with a higher radioactivity of uranium in Stei region. Moreover the second very high maximum of 1231 Bq/m^3 from Figure 3 shows clearly that in some cases the men were utilized as building materials (probably as ground walls or as filling) the uranium waste arising from Baita uranium mine. All 15 dwellings forming this group are built after 1950.Many measurements are still necessary for a good characterization of this area.

CONCLUSSION

Rather high indoor radon concentration in Transylvania region comparing with other European countries [13] and according with Scandinavian [14] and Ukrainian [15] values were found.
Generally the values for indoor radon are two times higher in the cold season as in the warm season in direct connection with the tendency to preserve the heat. This ratio was found for all three areas investigate.
The using of some materials with grown uranium content even of uranium waste as building material is evidently for Stei area where high and very high average indoor radon concentrations were measured.

REFERENCES

1. Ball, T. K. and Miles, J. K. H. (1993). Radon in southwestern of England. *Environ. Geochem. Health*, **15**, 27-36.
2. Bodansky, D., Robkin, M. A. and Stadler, D. (1990). *Indoor Radon and its Hazards,* University Washington Press, Seatle and London, U.K.
3. Samet, J. M., Pathak, D. R., Morgan, M. V., Key, C. R., Valdivia, A. A. and Lubin, J. H. (1991). Lung cancer mortality and exposure to radon progeny in a cohort of New Mexico underground uranium miners. *Health Phys*, **61**,745-752.
4. Sevec, I., Kunz, E., Tomasek, L., Placek, V. and Horacek, I. (1988). Cancer in man after exposure to Rn daughters. *Health Phys.* **54,** 27-46.
5. Tirmarche, M. (1996). Radon et risque de cancer. Etudes epidemeologique apres exposition professionelle on domestique. *Radiation and Society*, *International Atomic Energy Agency. Vienna.* Vol.2, 397-398.
6. Axelson, O., Anderson, K., Desai, G., Fagerlung. I., Jansson, B., Karlsson, C. and Wingreg, G. (1988). Indoor radon exposure and active and passive smoking in relation to the occurrence of lung cancer. *Scan. J. Work Environ. Health*, **14** ,286-292,
7. Messen, G:, Poffijn, A., Uyttenhove, I. and Buysse, I. (1995). Study of a passive detector for retrospective radon measurements. *Radiation. Measurements*, **25**, 591-594.
8. Samuelsson, C. (1988). Retrospective determination of radon in houses. *Nature,* **334**, 338-340.
9. Svensson, C., Pershagen, G. and Klaminek, I. (1989). Lung cancer in women and type of dwellings in relation to radon exposure. *Cancer Res.*, **49**, 1861-1865.
10. Auvinen, A., Makelainen, I., Hakama, M., Castren, O., Pukkala, E., Reisbacka, H. and Rytoma, A. (1996). Indoor radon exposure and risk of lung cancer: a case-control study in Finland. *Cancer Inst.* **88**, 966-972.
11. Samet, I. M. (1989). Radon and cancer. *I. Natl. Cancer Institute*, **81**, 745-757.
12. Cosma, C., Poffijn, A.,Jurcut, T.,Ristoiu, D., Coroian, D. and Buda, R. (1997).Radon and lung cancer risk-An epidemiological study in Romania. *Balkan Phys. Lett.*,**5**, 1693-1697.
13. NRPB (1993). *Natural Radiation Maps of Western Europe*, National Radiological Protection Board, Chilton, Didcot, Oxon.
14. Perhagen, G., Liang, Z., Hrubek, Z., Sevensson, C. and Boice, J. (1996). Residential radon exposure and lung cancer in Swedish women. *Health Phys.*, **63**, 179-186.
15. Paveklo, T. A. and Los, I. P. (1995).Indoor Rn-222 levels and irradiation doses on the territory of Ukraine. *Radiation Measurements*, **25**, 595-600.