INDOOR RADON CONCENTRATION IN POLAND

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INTRODUCTION

Preliminary survey of Rn concentration indoors by means of track detectors and γ-ray dose rate with the use of TLD in almost 500 homes in selected areas of Poland was performed in the late 1980s [1]. It was concluded that radon contributes 1.16 mSv i.e. about 46 per cent of the total natural environment ionizing radiation dose to the Polish population.

Comparison of the average radon concentrations in 4 seasons of a year and in 3 groups of buildings: masonry, concrete and wood, revealed that the ground beneath the building structure is likely the dominant source of radon indoors.

Since the National Atomic Energy Agency in its regulations of 1988-03-31 set up the permissible limit of the equilibrium equivalent concentration of radon in new buildings (equal 100 Bq/m^3), the nation-scale survey project for radon in buildings has been undertaken. These regulations were supposed to take effect in 1995-01-01.

The project has 3 objectives:

- to estimate the radiation exposure due to radon daughters received by Polish population
- to identify radon-prone areas in Poland
- to investigate dependence of the indoor radon concentrations on such parameters as: type of construction material, presence (or absence) of cellar under the building, number of floor.

So far the measurements have been made in 5 macroregions of Poland:

1.Białystok, 2.Gdynia, 3.Katowice, 4.Warszawa, 5.Wrocław (Fig.1).

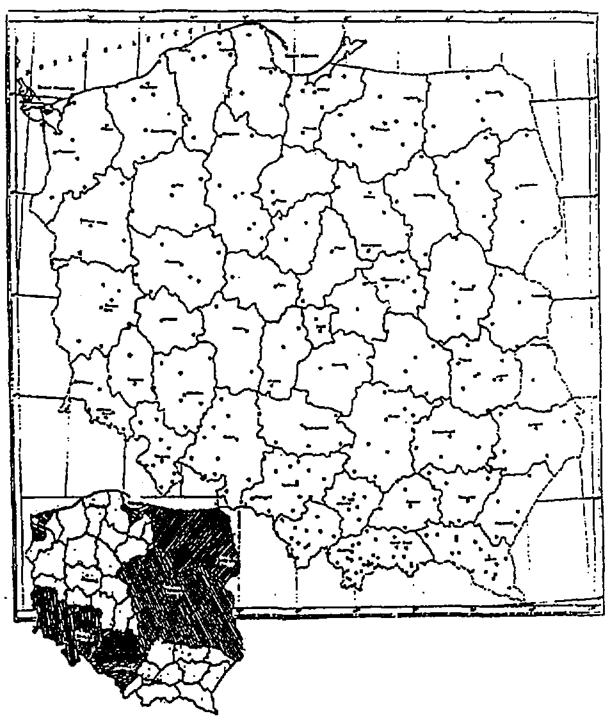

Fig. 1: Distribution of meteorological stations. Marked area was covered by the survey.

POPULATION SAMPLING

On the basis of our previous experience we assessed that distribution of radon detectors by mailing them to randomly selected people would be not effective in our country. Therefore we decided to make use of the network of 340 meteorological/climatological stations of the Institute of Meteorology and Water Management uniformly covering an area of the country. The station staff distributed radon dosemeters and questionnaires in 15 homes in the vicinity of each station and also took care about the outdoor measurements of Rn in the stations. Such distribution system gives a stochastic rather than a random sample of housing stock but owing to it only 14 per cent of the detectors were lost.

The radon survey questionnaire contains the following questions on:

1. type of house (one family house, multiple family dwelling, multi-storey block)
2. presence (or absence) of cellar in the house
3. type of construction material (wood, red brick, hollow-ash fly brick, prefabricate-concrete technology)
4. year of construction
5. the floor at which the surveyed dwelling was located
6. number of people living in the dwelling.

The meteorological staff who distributed the dosemeters wrote down the date of start, end of the exposure and the dosemeter number.

METHOD

An integrating method of solid state track detector based on the Pershore CR-39 foil placed at the bottom of the Karlsruhe type diffusion chamber with a diffusion barrier (Schleicher & Schüll filter) has been used. The time of exposure was 6 or 12 months. After exposition, CR-39 detectors were chemically etched in 10 N NaOH solution at 70°C for 8 hours. The alpha-tracks were counted by means of an automatic computerized reader [2], designed and developed at our laboratory, in an area of 4.16 mm^2 corresponding to 16 fields of view.

The method is calibrated using a barrel-shaped chamber of 320 dm^3 and dry Pylon ^{226}Ra source of activity of $3.71 \cdot 10^6$ pCi, with the error of 4 % at 99 % confidence level. On the basis of 10 calibration exposures the sensitivity $k = (29.6 \pm 0.7)$ $kBq \cdot h \cdot m^{-3}/tr.mm^{-2}$ was found, with the average background track density equal 1.6 ± 1.4 $tr.mm^{-2}$ (range: 0.2 - 3 $tr.mm^{-2}$). Low level detection limit of this method, assumed as 3 standard deviations of the background track density, is estimated to be 34 $kBq \cdot h \cdot m^{-3}$ which corresponds, for an exposure time of 12 months, to the radon concentration of 4 $Bq \cdot m^{-3}$.

Track density is converted to $Bq \cdot m^{-3}$ by means of the formula: $E = -48.05 + 29.6\ N$ where E is an exposure in $kBq \cdot m^{-3}$ and N is a gross number of tracks per mm^2.

For the exposure time of 6 months (4380 h) we obtain: $S_{Rn} = -0.011 + 0.007\ N$. The method was verified in the First International IAEA-US EPA Passive Radon Detector Intercomparison (October 1991) with the average performance ratio equal 1.07 and in the Second International IAEA-US EPA Intercomparison (July-September 1994) with the participant to BOM target ratio equal 1.0 (in the Twilight Mine, Colorado) and the participant-to EPA target ratio equal 0.89 (at the EPA Las Vegas Laboratory).

RESULTS AND CONCLUSIONS

Presented results of radon concentration indoors refer to 5 macroregions: Katowice, Białystok, Gdynia, Warsaw and Wrocław which constitute about 46 per cent of the area of Poland and are inhabited by about 60 per cent of Polish population. In these regions above 2000 dwellings were covered with the survey.

The results are shown in Figs 2-5.

The lognormal distribution is a good approximation of the distribution of radon concentration with a geometrical mean of 32 Bq/m^3 and an arithmetical mean of 41 Bq/m^3 corresponding to an effective dose of about 1 mSv/y [3]. The highest values in the range from 200 to $500/m^3$ constitute about 2 per cent of all results. Most of them appear in 2 voyvodships: Wałbrzych (with arithm. mean of 71 Bq/m^3) and Jelenia Góra (with arithm. mean of 69 Bq/m^3) in the southern part of the Wrocław region.

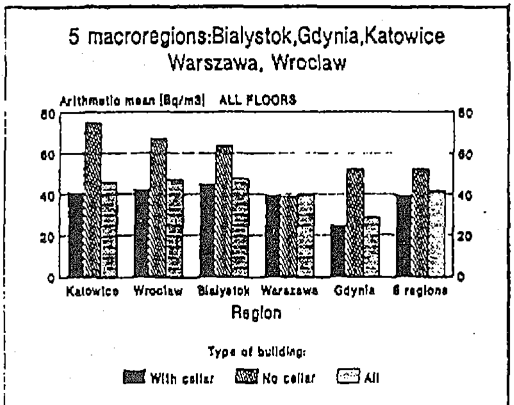

Fig.2. Rn conc.vs.type of building (with cellar, without cellar, all)

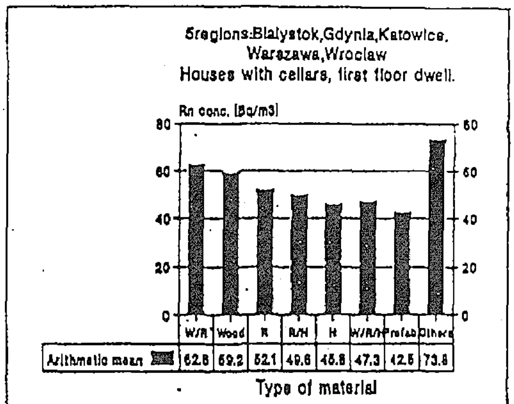

Fig.4. Rn conc. vs. type of material
W-wood; R-red brick; H-hollow brick;
Prefab.-prefabricates.

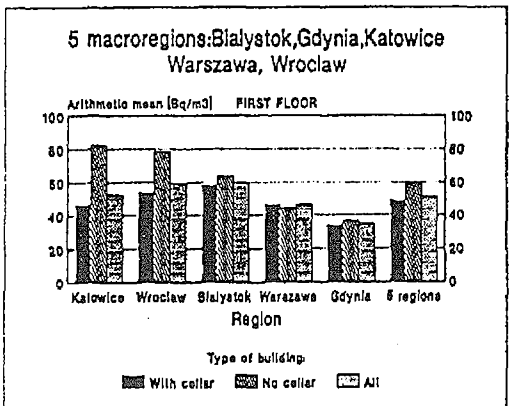

Fig.3 Rn conc.vs.type of building (with cellar, without cellar, all)

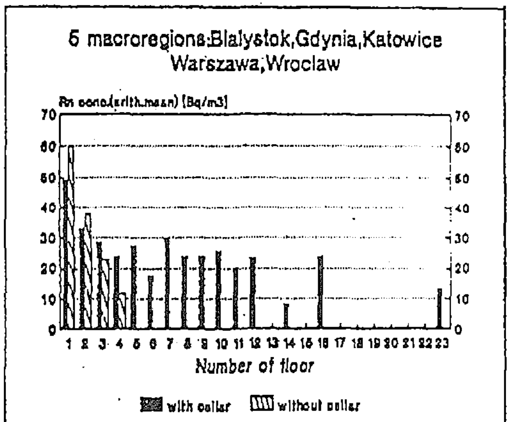

Fig. 5. Rn concentration vs. floor

Fig. 2 - Fig. 5.

	Total	Katowice	Wrocław	Białystok	Warszawa	Gdynia
Number of flats	2081	326	429	306	727	281
Arithmetic mean	41.2	45.5	47.3	47.1	39.8	28.0
Geom. mean	32.0	34.9	32.2	31.6	32.7	23.2
Area [km^2]	123087	17477	30454	40272	30454	4430
Area [%]	46	6.5	11.4	15.0	11.4	1.7
Population x 10^3	23573	5554	3863	2097	10446	1613
Population [%]	60.4	4.2	9.9	5.4	26.8	4.1

Table 1: Radon concentration indoors [Bq/m^3]. Statistical information.

The mean values for non-cellar buildings are significantly higher than for cellar buildings (Figs 2-3). Cellars themselves were not tested because they are usually not inhabitable in Poland.

Radon concentration decreases when number of floor increases (Fig.5). It is true for each of 5 „type of material" groups of buildings.

The mean value is the highest in the group of buildings constructed of wood and red brick and is the lowest in the group of concrete buildings (called „prefabricate").

ACKNOWLEDGEMENT

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