THE RADON SURVEY AND ITS CONTRIBUTION TO THE RADIATION EXPOSURE

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INTRODUCTION

Nowadays, the change of life conditions, the intense increase and diversified pollution of the environmental factors have a complex effect over the health status of the population. A compound of pollutants produces a stronger negative effect than the virtual sum of its components taken separately, determining their investigation as a whole. Radioactive pollution and exposure to natural and artificial radiations play a distinct role among the contemporary health hazards. It is well known that the most important contribution to human exposure to the ionizing radiations of natural origin is due to ^{222}Rn and its short-term daughters (1). In the 80's, this nobel gas was discovered to be accumulated mostly in the indoor air of the buildings. The accumulation of these radionuclides in dwellings depends on some factors such as: geochemical and geophysical properties of the sol where is the location of the construction, the building materials, the nature of the building foundation, the type of dwellings, the dimensions of rooms, the rate of ventilation, the radon and radium content of the tap water, type of heating used and the living and working conditions (2).

In this study we present the level of radon concentration in different types of buildings. Based on our results we estimated the yearly effective dose equivalent for these groups of the population.

MATERIAL AND METHOD

Two types of dwellings were taken under study: detached houses (built in 1920) and a ten floor block-of-flats, (built in 1970), in Cluj-Napoca situated in an area with "normal" radiation background. These buildings are characteristic for Transilvania, Romania. Cluj has 350000 inhabitants and according to the statistical data from 1992 the proportion of the population living in detached houses is 36 %.

The walls of the detached houses are made red brick while stone and slog were used for the basement. There is a cellar under the kitchen of the house I. In 1975, a new room (C) was attached to the old building (room A and B), having brick-made walls, while the basement, the floor and the ceiling were made of concrete. The rooms were the same volume 5m x 5m x 3.5m. Natural gas is used for cooking and heating. The block of flats is built out of prefabricated elements and all the flats have central heating. The living rooms volume are 4m x 4m x 2.5m.

The determinations of the ^{222}Rn content were performed under normal living conditions, in the autumn of 1994 using the "PRASSI - Portable Radon Survey Meter" instrument. The air samples were collected in the middle of the premises, at 0.5 m from the floor. In order to assess and compare the values of the indoor ^{222}Rn concentrations, measurements were performed in the outside as well, at 0.5 m from the ground, during the same period of time.

We estimated the Effective Dose Equivalent (EDE) of the people considering the internal dose absorbed in respiratory tract from radon and its daughters. The following assumptions has been made: the mean radon concentrations -determined in autumn- represent a yearly average, the equilibrium factor between ^{222}Rn and its daughters is 0.5, people spend 19 hours/day in dwellings, the mean inhalation rate of people is considered to be 14 l/min (3,4). The annual number of the expected lung cancer cases induced by radon daughters exposure can be calculated based on our results and the absolute lung cancer risk (5).

RESULTS AND DISCUSSION

The mean values of ^{222}Rn concentrations in the inside and outside of the buildings are shown in table 1. The indoor values are significantly higher in the rooms A,B (house I) and A' (house II) as compared to those found in the other rooms in detached house or to the block of flats.

The building materials being identical for the rooms, the bathroom and the kitchen, the high differences between

^{222}Rn concentrations could be explained by the dissimilarities in their respective basements.

Beneath the rooms A,B and A', the high porosity pavement made of stone and slag allows this noble gas to easily spread and reach the interior of the rooms. Moreover, the room B has only one wall in direct contact with the outside air so that the speed of the indoor natural air exchange is lower than in room A, that has two free walls

Table 1 ^{222}Rn CONCENTRATION IN FAMILY HOUSES AND BLOCK OF FLATS

PLACES	NUMBER OF SAMPLING	NUMBER OF MEASUREMENTS	Rn-222 CONCENTRATION (Bq/m^3)		
			MEAN ± SD	MIN.	MAX.
DETACHED HOUSE					
1. Room A	1	351	335 ± 76	22	520
Room B	2	151	436 ± 109	42	585
Room C	5	62	91 ± 20	27	124
Kitchen	4	90	45 ± 11	14	85
Bathroom	3	55	85 ± 25	47	162
2. Room A'	-	78	799 ± 293	310	1316
BLOCK OF FLATS					
Ground floor	-	4	70 ± 25	52	88
First floor	-	72	61 ± 14	19	90
Four floor	-	8	65 ± 25	50	81
Seven floor	-	41	49 ± 11	21	70
Eight floor					
Room	1	125	68 ± 20	23	102
Kitchen	2	66	61 ± 15	33	97
Bathroom	3	5	101 ± 14	81	117
OUTDOOR	6	50	29 ± 12	14	39

and, therefore, a lower air ^{222}Rn concentration. The ^{222}Rn concentration is approximately 7.5 times lower (45 Bq/m^3). This could be explained partially by the presence of the cellar under the kitchen (where the diffused underground ^{222}Rn is temporarily deposited and easily evacuated through the windows of the cellar into the open air) and partially by the fact that the kitchen, by its function, is more frequently ventilated. The daily variations of the radon concentration in the kichen's air are show in Figure 1.

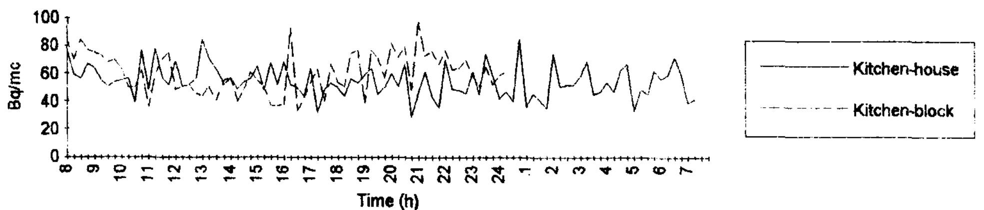

Figure 1. Distribution of radon concentration in kitchens' air.

The bathroom has no outside walls and there is no cellar under it, but the ^{222}Rn concentrations in the air are approximately 4.5 times lower as compared to those found in the rooms A and B, due to a permanently opened ventilation aperture through the chimney. Measurements in the air of the bathroom after running the shower for 15 minutes proved an increase in the radon concentration of 20 Bq/m^3.

Finally, the ^{222}Rn concentration in room C, being 3...4 times lower than those measured in the rooms A and B, can be explained by the presence of a concrete foundation that plays the role of a screen for the ^{222}Rn coming out from the soil.

Regarding the ^{222}Rn concentrations found inside the block flat, a lowering of the values along the first floors and a slight increase of them at the upper levels are to be noticed. The overall values are 2...3 times smaller than those measured in the detached house.

Out of the measurements performed in the initially ventilated rooms, during standard periods of 24 hours, it can be noticed that during the first 3 hours after closing the windows and the doors, the speed of ^{222}Rn accumulation is 50 Bq/m^3/hour in room A and approximately 90 Bq/m^3/hour in room B followed by a slower accumulation, of 22 and, respectively, 28 Bq/m^3/hour, determined during a 9 hour period. Sudden decreases of ^{222}Rn concentrations after the opening of the windows have been observed in all sampling points. During the first 15 minutes of natural ventilation, the concentrations reached values similar to those measured in the open air (Fig.2).

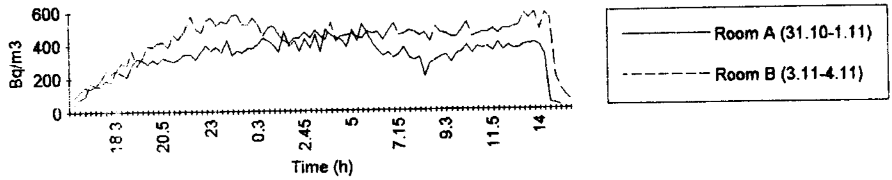

Figure 2. Radon accumulation in living rooms.

The deviations of the daily means from the previous day mean value ranged in the 10...24 % interval.
We have estimated respiratory system doses attributable to the inhalation of the radon and its daughters in dwellings for the investigated population groups from Cluj-Napoca (0.35 to 16..54 mSv/y). The maximum value of was obtained for people who live in detached houses. In Table 2. we give the Equivalent Dose Effective (EDE) and the weighted averages and the lung cancer risk for these groups of people.

Table 1. WEIGHTED AVERAGE ANNUALE EQUIVALENT DOSE EFFECTIVE INDUCED BY INHALATION OF ^{222}Rn DAUGHTERS AND LUNG CANCER RISK

BUILDING	INHABITANTS	EDE (mSv/y)		LUNG CANCER EXPECTED
DETACHED Ground floor (with cellar) (without cellar)	126000	2.99 6.50	2.47	7.41
BLOCK Ground floor First floor Four floor Seven floor Fight floor	224000	1.06 0.79 0.76 0.76 0.69	0.76	2.71

CONCLUSIONS

The measured values of indoor radon concentration have demonstrated that the high concentration levels in similar conditions can be attributed to radon entering the house through the building foundation.

Measurements of the ^{222}Rn concentrations in the indoor air of the same detached building showed values with a great variation. In the rooms with stone and slag basement, the ^{222}Rn concentration exceeded the value recommended by ICRP 65/95 (the recommended action level for the annual average radon concentration in air in dwellings should not exceed 200 Bq/m^3) (7).

In the future the increasing indoor exposure of the population to radon and its daughters might be the consequence of a reduced ventilation by mean of the energy conserving measures and utilizing the new building materials

Determining the radon concentration as well as the origins of the indoor radon contribute to finding out the solutions for reducing ar most the risk due to ionizing radiations.

The significance of radon for the human health is well known and thus the measurement of indoor radon is important for the evaluation of its impact in the public health field. A difficulty in evaluating the risk of lung cancer is the evaluation of the cumulative exposure. The relationship between radon, its daughters exposure and other carcinogenic pollutants is still uncertain.

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REFERENCES

1. St.J.Wozniak, *Handbook of radon, health, economic and building aspects,* ISBN-1992, London (1992)
2. I.Mocsy, N.Muntean, E.Muntean and A.Vasarhelyi, *Indoor Climate of Buildings,* Slovakia (1992)
3. G.Keller, K.H.Folkerts and H.Muth, *Radiat.Environ.Biophys.* 20, 263-274 (1982)
4. G.Keller, K.H.Folkerts and H.Muth, *Radiat.Protec.Dosimet.* 7(1-4), 151-154 (1985)
5. S.Y.Chang, C.W.Ha and B.H.Lee, *Radiat.Protec. Dosimet.* 42 (2), 127-132 (1992)
6. x x x Protection against radon-222 at home and at work, *ICRP 65* (1995)