7. Spitz, H.B., Wrenn, M.E. and Cohen, N. Diurnal variation of radon measured indoors and outdoors in Grand Junction, Colorado and Teaneck, New Jersey and the influence that ventilation has on the buildup of radon indoors. In Natural Radiation Environment III, Technical Information Center/USDOE Conf. 780422 (1980), 1308-1330.

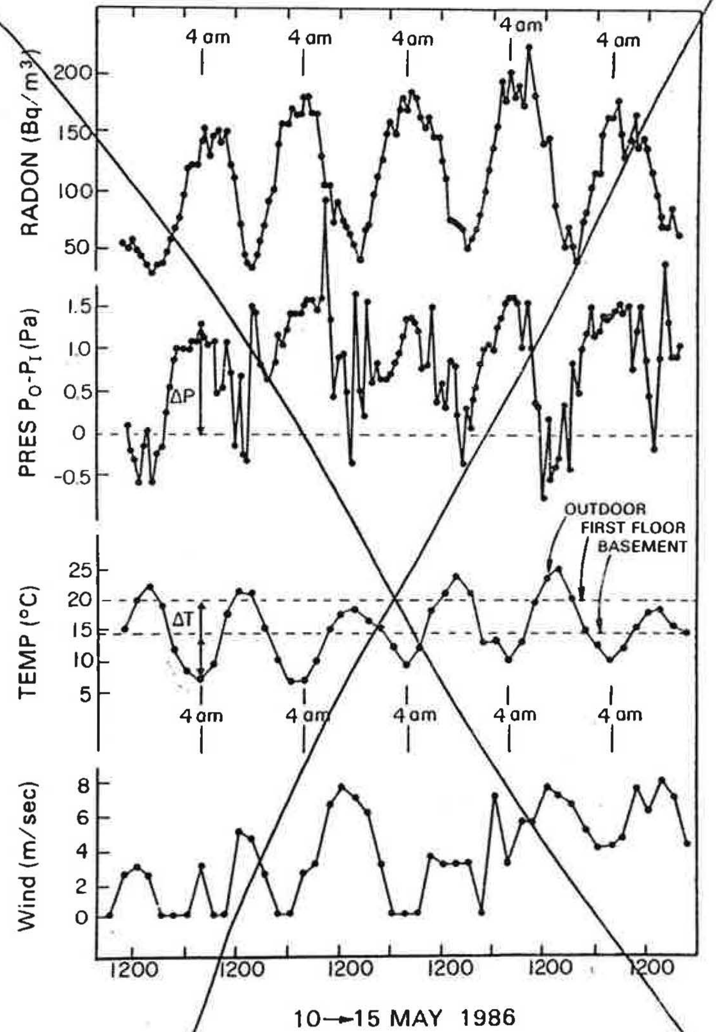


Figure 1. Measurements made during a 5 day period in the spring for a home in northeastern U.S.. Radon concentrations were measured for the first floor and the pressure differential was measured between the outside air and the basement. Outdoor temperatures and wind speeds were obtained from a nearby weather station.

THE INFLUENCE OF VENTILATION IN ROOMS UPON THE EFFECTIVE DOSE EQUIVALENT FROM INHALATION OF ^{222}Rn AND THEIR SHORT LIVED DAUGHTERS

Ildiko Mocsy and Corina Fulea
Institute of Hygiene and Public Health, Radiohygiene Laboratory, Cluj-Napoca, R.S.Romania

Krisztina Simon
Epidemiological Hygiene Country Unit, Department of Radiation, Cluj-Napoca, R.S.Romania

Abstract

Results are presented of measurements of the activity concentrations of ^{222}Rn and its short-lived decay products in apartments with prefabricated panel walls and simultaneausly in the open air. The median value of the ^{222}Rn concentrations in the open air was found to be about 7,6 Bq m^{-3} ranging from 2,7 up to 1o,5 Bq m^{-3}. The variation of the ^{222}Rn due to ventilation were investigated by measurements inside a room with very poor ventilation (after 48 hours windows and doors closed) 166 Bq m^{-3} end a room with strong ventilation 31 Bq m^{-3}. The equivalent dose for members of the public due to inhalation of radon's short lived daughters indoors was about a factor of 4,4 higher than the dose calculated for members in open air.

Introduction

Natural background sources represent the greatest contributors of radiation exposure to the world's population today. The highest contribution to the natural internal radiation exposure (53,6 %) is delivered by inhalation of the short lived ^{222}Rn. ^{222}Rn is a radioactive gas produced by the decay of the ^{226}Ra, it is present naturally everywhere in soil and rock, in various concentrations from on place to another. The typical building materials are commonly made from there naturel materials (sand, rocks, cement). Several new building materials with relatively high radium concentrations have been used in recent years (red mud, phosphogypsum, zircon products and fly ash). The radon gas diffuses through the pores of the soils, rocks and building materials will escape into the sorrounding atmosphere. The concentration of radon and daughters is usually low in the free atmosphere, because dispersion rapidly takes them away from the surface, but if the radon escapes into confined spaces enhanced levels results. The consideration of these radionuclides is necessary when determining the background radiation level to the population (1,4).

The inhaled ^{222}Rn gas itself and free radon daughters (very mobile in air) are rapidly deposited and irradiated different parts of the respiratory system. Others become attached to aerosol particles present in the atmosphere and are first deposited throughout the respiratory tract; the principal tissue irradiated is the basal cell region of the bronchial epithelium. Part of this deposit passes into the blood stream and is transported to the various organs and tissues, whose radiation burdens are lower but not neglijable (2,5).

In this work, the results of measurements of the activity concentrations of ^{222}Rn and its short-lived decay products in an apartment and simultaneously in the open air are presented. We investigated the variations of radon and their daughters concentrations under different ventilation conditions. We also made some evaluations of the doses to the respiratory tract from the inhalation of these radionuclides.

Material and methods

In this study, about 1oo measurements of the concentrations of ^{222}Rn and its short-lived alfa decay products were made in ground floor apartments with prefabricated panel walls, recently constructed, the dwelling is situated in a region with a normal radiation background, in a municipality called Cluj-Napoca. There radionuclides measurements were performed in two week periods in the summer time. During this experiment there was not heated in the apartment, so that the radon concentration would be supplied by other sources. The air samples were collected between 1o-14 hours, thus we have neglected the possible effects of wind, thermal stability, atmospheric scavenging and precipitation from the radon concentration. Two air sampling units were installed simultaneously thus to permit collections and measurements parallel to indoor and outdoor. All the samples were made at a high of 1 m above the floor and at a height of 2 m above the ground. The concentrations of the ^{222}Rn and ^{222}Rn

daughters were determined by air sampling on a membrane filter (pore size 1,5 μm). A known volume of the air is drown through the filter (5 min) at a rate of 3o $l.min^{1}$. The alfa activity deposited on the surface of the filter was performed in three measuring intervals over filtration to 5, 15 and 3o min, by a disc of the plastic detector. The activity concentrations of the short lived ^{222}Rn canbe calculated from the members of counts. When the activity concentration of ^{222}Rn and daughters is known, the working level (WL) values can be calculated. The WL is commounly used to indicate the potential alfa energy concentration in an air volume (6). The measuring device was calibrated by an ^{241}Am sheet reference source.

The ^{222}Rn and their daughter concentrations in room depends of: natural radiation rate, radium content of the building materials, ^{222}Rn diffusion coeficients, aerosol concentrations and the area volume of the room. The natural ventilation rate was determined through the parallel measurements of the ^{222}Rn individual daughter product concentrations inside a room after strong ventilation and when the window and the door in the room was closed for 3 hours (the ^{226}Ra concentration and rates of radon exhalation from our prefabricated panel is acquaintance). The ratio of the concentration of ^{222}Rn itself and daughter nuclides is the equilibrium factor. For simultaneously measured values of this radionuclides the equilibrium factor could be established (3). The artificial ventilation was ensured by opening and shutting of doors and windows during the period for 1 to 48 h.

Based on the measured median activity concentrations of the ^{222}Rn and ^{222}Rn daughters the expected mean annual lung and the basal cells doses were calculated. The mean residence time of 19 h per day (o,8 the occupancy factor) and 5 h per day in the open air (o,2) and mean respiration (13,8 l min) rate was assumed for a standard man. Applying the dose conversion factors we can estimate the probable range of the annual effective dose equivalents due to inhalation of ^{222}Rn and short lived ^{222}Rn daughters for members of the public.

Results

Fig.1 shows the mean daily value for the ^{222}Rn concentrations and temperature for a ten day period in the open air, under normal meteorological conditions. This value was found to be about 7,6 $\pm$ 1,1 Bq m^{-3} ranging from

2,6 up to 1o,5 Bq m^{-3}. The median values of the daughter product concentrations were found to be about 7,1 $\pm$ o,9 (^{218}Po), 4,5 $\pm$ 1,1 (^{214}Pb) and 2,7 $\pm$ 1,4 (^{214}Bi) Bq m^{-3}. The median value of ^{222}Rn concentration inside, when usual ventilation (o,1 h^{-1}) was determined at 31, 3 $\pm$ 4,1 Bq m^{-3} was about a factor of 4,1 higher than in the open air.

It can be shown (Fig.2) from ^{222}Rn accumulation that they increased from 7,6 Bq m^{-3} to 6o Bq m^{-3}, when doors and windows are closed from 1 to 2o hours. The mean of the decay products in this period was found to be about 33, 2 $\pm$ 1,9 ^{218}Po, 27,o $\pm$ 2,1 ^{214}Pb and 2o,1 $\pm$ 1,1 ^{214}Bi Bq m^{-3}. A rapidly increased of ^{222}Rn concentration was observed after 24 hours (131 Bq m^{-3}) the room was not ventilated over night (^{21o}Po = 73,5 $\pm$ 2,2; ^{214}Pb= 58,o$\pm$2,o; ^{214}Bi = 27,1 $\pm$ 1,8 Bq m^{-3}). The heighest values of the activity concentrations were obtained after 48 hours ^{222}Rn = 166 Bq m^{-3}, ^{216}Po = 92,9 $\pm$ 3,3, ^{214}Pb = 63,9 $\pm$ 1,6, ^{214}Bi = 27,o $\pm$ 1,8 Bq m^{-3}. The higher values of the ^{222}Rn and ^{222}Rn daughters concentrations found in the room could be attributed to the exhalation radon of the walls and inadequate ventilation. In the second stage of measurements average value of the ^{222}Rn and decay products concentrations diminished during to 3 hours, when ventilations was induced through opening the windows, so there wan't be difference between ^{222}Rn concentration inside and outside air. The median value of equilibrium factor from all measurements in dwelling was found to o,33-o,88 in the different ventilation conditions, whereas the median value of equilibrium factor in the open air was determined at o,47 - o,61. An equilibrium factor of about o,4 was calculated for ventilation rates of o,1 h^{-1}, it is representative for these buildings.

To evaluate the dose to the respiratory organs we used to the concentration of the radon and short lived radon daughters. Indoors, the median values of ^{222}Rn and potential alpha energy concentration of the ^{232}Rn daughters and the dose calculation results are shown in Table 1.

The results shows, that the contribution of the ^{222}Rn (o,3 %) schould be negleted when estimates of the effective dose equivalent from natural airborne radioactivity in dwellings are performed. The greatest contributors are the short-lived decay products of ^{222}Rn (99,7 %).

The equivalent dose for members of the public due to the inhalation of radon's short lived daughters indoors was about a factor of 4,4 higher than the dose calculated for members in open air.

Table 1 Mean annual effective dose equivalent due to the continuous inhalation of ^{222}Rn and ^{222}Rn daughters

VENTI-LATION	CONC.OF ^{222}Rn (Bq m^{-3})	EFFECTIVE DOSE EQUIVALENT TO LUNG (μSv . y^{-1})	CONC.OF ^{222}Rn DECAY PRODUCT (mWL)	EFFECTIVE DOSE EQUIVALENT TO BRONCHIAL EPITHELIUM;LUNG (m Sv. y^{-1})		TOTAL EFFECTIVE DOSE EQUIVALENT (mSv. y^{-1})
INDOOR CLOSED TIME (h)						
2	33,6	1,75	3,6	o,5o	o,13	o,63
2o	59,8	3,12	6,5	o,89	o,23	1,12
24	131,2	6,84	14,o	1,93	o,49	2,42
48	166,1	8,66	18,o	2,48	o,93	3,42
OUTDOOR OPEN AIR	7,6	o,4o	o,8	o,11	o,o3	o,14

Conclusions

The results in this paper show; the median value of ^{222}Rn and decay products when usual ventilation, was about a factor of 4,1 higher than in the open air. The concentrations of these nuclides versus the inverse of ventilation rate. The equilibrium factor obtained was : o,47 - o,61 outdoors and o,33 - o,88 indoors under various ventilation conditions.

An increase in the ventilation rate over a short period of time may reduce the ^{222}Rn short-lived decay product concentrations and the respiratory tract doses to the inhabitans considerably.

References

1. Abu-Iarad F. and Fremlin J.H. The indoor concentration of radon daughters in there different areas of the U.K.- Health Physics 44 (1983), 479-485

2. Keller G., Folkerts K.H. and Muth H. Activity concentrations of ^{222}Rn, ^{220}Rn and their decay products in German dwellings, dose calculations and estimate of risk. Radiat.Environ.Biophys. 2o (1982), 263-274

3. Keller G. and Folkerts K.H. Radon-222 concentrations and decay product

equilibrium in dwellings and in the open air. Health Physics 47 (1984), 385-398

4. Mustonen Raimo. Natural radioactivity in and radon exhalation from Finnish building materials. Health Physics 46 (1984) 1195-1203

5. Pohl E. Dose calculations due to the inhalation of ^{222}Rn, ^{220}Rn and their daughters. Health Physics 32 (1977), 552-555

6. Virágh E. and Zöld E. Radicactiv szennyeződések hatása a környezetre. Budapest 1980

Fig1 Mean daily (10-14h) ^{222}Rn concentration and temperature outside air, during a period of ten days

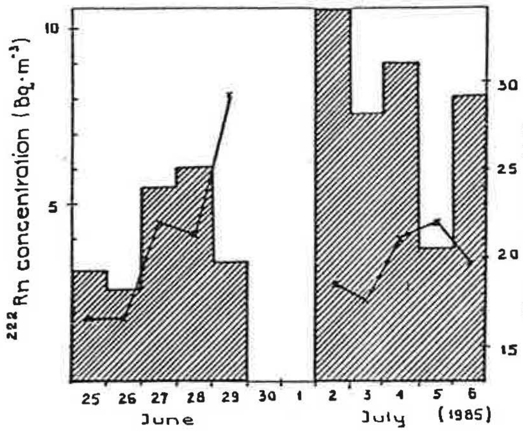
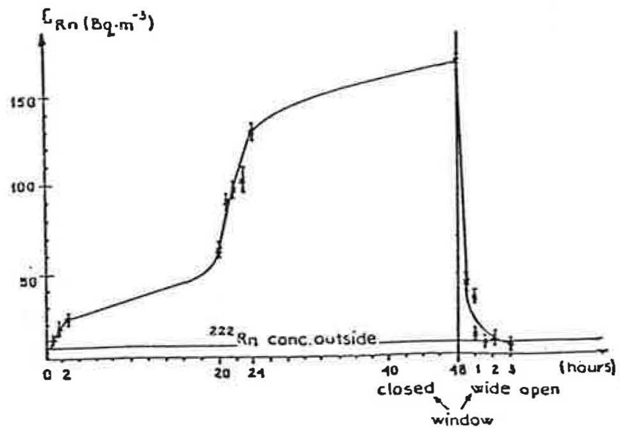


Fig.2 Mean ^{222}Rn concentration in a 51 h period inside, for different ventilation conditions



EXPERIENCE FROM INDOOR RADON-DAUGHTER LIMITATION SCHEMES IN SWEDEN

Gun Astri Swedjemark
National Institute of Radiation Protection, Stockholm, Sweden

Håkan Wahren and Astrid Mäkitalo
National Board of Health and Welfare, Stockholm, Sweden

Wilhelm Tell
National Board of Physical Planning and Building, Stockholm, Sweden

Eva Melander
Swedish Association of Local Authorities, Stockholm, Sweden

Abstract

In Sweden a limitation scheme for radon daughters has been in operation since 1980. This paper describes the limitation scheme. The radon daughter concentrations found by the local authorities up to 1986 in their search for houses with levels above the limit is compared with the results from a previously reported country-wide study carried out during the years 1980-1982 with the aim of being representative. Up to November 1986 more than 40,000 homes had been investigated and of those about 4600 had radon daughter concentrations above 400 Bq/m^3 and several hundred had levels above 2000 Bq/m^3.

Introduction

In Sweden the search for homes with high levels of radon daughters has been since 1980 carried out by the local public health authorities. The results of this search up to July 1982 have been reported earlier (2, 3). A few local authorities have completed the search and then made measurements in most of the existing houses suspected of having high levels.

Limits and recommendations

Since 1980 Sweden has had limits with the aim of reducing the exposure to radon daughters and the gamma radiation in homes. For existing houses with levels exceeding 400 Bq/m^3 of equilibrium equivalent concentration of radon (EER) the houses are declared as insanitary with respect to radon. In this paper the EER is called the concentration of radon daughters. There is also a recommendation that measures should be taken in homes with radon daughter levels between 100 and 400 Bq/m^3 when this can be done with simple measures.

For planned houses the radon daughter concentration should be lower