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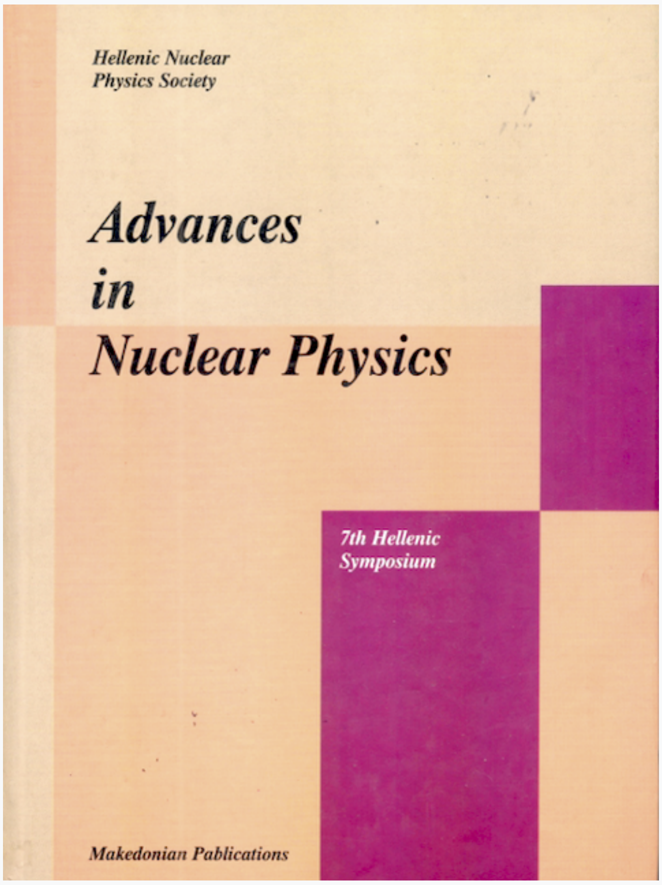

A Study of Cover Materials Which Influence Rn222 Exhalation Indoors

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A Study of Cover Materials Which Influence Rn^{222} Exhalation Indoors

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Abstract

The wall covers can decrease or increase the radon exhalation; this depends on whether the material acts mostly as a sealer against radon exhalation or as a source of radon. This work is a study of different kind of wall covers which influence radon exhalation from surfaces of building materials. The experimental data are in good agreement with the evaluations according to the theory of radon diffusion through porous materials.

1 Introduction

The average annual effective equivalent dose from radon inhalation is of the order of 1 mSv which is the 50 % of the doses caused annually by natural sources (**UNSCEAR 1988**). The main radon sources are soil and building materials that contain certain amounts of Ra226. Because of radon accumulation in room air, radon inhalation indoor gives the most significant contribution to the total dose caused by radon. Ra^{226} is the source of Rn^{222} as it decays with alpha emission. Rn^{222} is a noble radioactive gas with half life 3.8 days which is long enough for part of it to diffuse from building materials to the inside of the room. The internal wall decoration used to cover the building materials will act in such a way as to decrease or increase this emanation. This depends on whether the material acts as a sealer against radon emanation or as a source of radon. It has been found that marble powder acts as sealer and cement plaster acts mostly as a source of radon. The effect of paints on the radon exhalation depends on the characteristics of the paint as well as on the building material that is painted.

The factors that influence the radon concentrations in room air are:

1. The properties of the building materials. The radon exhalation depends

on the Ra^{226} concentration, the emanation and diffusion coefficient and the porosity of the material. Wall covers act as sealers against radon exhalation and as sources of radon when they contain Ra^{226} (Yu K. N. 1993, Abu-Jarad F. and Fremlin J. H. 1983).

2. Building construction. The indoor radon concentrations are influenced by the ventilation rate, which strongly depends on the properties of the building, such as the use of insulating materials, artificial ventilation system etc.

3. Meteorological parameters. These may influence the radon exhalation from the building materials as well as the ventilation of the buildings. Also the meteorological parameters act upon outdoor radon concentration due to the radon exhalation from soil (Stranden E. and Berteig L. 1980, Fleischer R. L. 1987).

In previous studies indoor radon concentrations in Athens (Kritidis et. al. 1994) and radon exhalation from building materials used in the Attica region have been determined (Savidou A. et. al. 1995 and Savidou A. et. al. 1996). In order to extend our study on building materials, the effect of using plasters and paints (common in Greece) on the exhalation of radon has been examined. The purpose of this work is to study the effects of wall covers, that are used in Greece, on radon exhalation from wall surfaces made of concrete and bricks. The technique used for the measurements of the radon exhalation is called "continuous accumulation-counting" and has been described in detail by the authors in earlier publications. This measurement technique is based on the continuous air flow through a sealed chamber containing the sample and through a scintillation counter (Lucas cell). The counting is continuous as well.

2 Examined Materials

The plasters that are examined are those commonly used in Greece. These are cement plaster (sand + cement) and marble powder. The types of paints selected for study represents 99 % of the indigenous consumption. These paints are an acrylic relief paint and two types of emulsion that differ only in the component that serves as a binder. The concentration of the binder that is PVA or acrylic, in an emulsion is of the order of 30 %. It is also examined an epoxy paint which has low porosity and small diffussion length. All the studied products are made in Greece.

3 Radon Exhalation Rate

The technique used for the measurements of radon exhalation is called "continuous accumulation-counting" (Savidou et. al. 1995) (Fig. 1) This measurement technique is based on the continuous air flow through a sealed chamber containing the sample and through the scintillation counter (Lucas cell) and the counting is continuous as well. The concentration of radon and its daughters in the counter increases with time. The accumulated counts are proportional to the time integral of the total alpha-activity in the counter. To prevent the counting of thoron (Rn^{220}), the samples are covered hermetically with a thin PVC membrane. The ratio of samples volume to the volume of the accumulation chamber has been 1:6 and the air flow rate has been 2 $l.min^{-1}$. The low limit (3σ of the background) of the radon emanation rate for counting time 24 h is 7 $mBq.h^{-1}$. The exhalation rates of radon from concrete and brick samples were measured before and after each coating. The concrete and brick samples had the same size. The concrete slabs were from the same mixture and the bricks from the same batch. The thickness of the cement plaster layer that was first applied on all the samples was 2 cm as is customary. The second layer was marble powder 1 cm thick and it was applied on all the samples. Consequently the samples were painted as follows:

(a) 1 brick and 1 concrete sample were covered with 1 coat of emulsion primer and 2, 4 and 6 coats of emulsion-PVA.

(b) 1 brick and 1 concrete sample were covered with 1 coat of emulsion primer and 2, 4 and 6 coats of emulsion-acrylic.

(c) 2 brick and 2 concrete sample were covered with 1 coat of emulsion primer and 1 coat of relief paint.

(d) 2 brick and 2 concrete sample were covered with 1 coat of epoxy primer and 2 coats of epoxy paint.

All the measurements have been carried out in laboratory conditions, in which the temperature is maintained at 20 °C and the relative humidity at 50 %, so significant effects due to changes in ambient conditions have been avoided. The samples before and after each stage of treatment have been kept for more than two months under laboratory conditions in order to achieve the same conditions for all the samples. After each stage each sample of treatment was measured at least five times.

4 Specific Activities

The concentrations of the natural radionuclide Ra^{226}, Th^{232} and K^{40} are determined by the use of high-resolution gamma spectrometry. The samples are powdered, closed in 75 cm^3 sealed containers and kept about 3 weeks before measurements in order to achieve radioactive equilibrium between Ra^{226}, radon and its short-lived decay products. The concentration of Ra^{226} is derived from the 295 keV and 352 keV photopeaks of Pb^{214} and the 609 keV photopeak of Bi^{214} as the mean value. The 186 keV photopeak of Ra^{226} is not used because of the interfering peak of U^{235}, with the energy of 185.7 keV. The Th^{232} concentration is determined from the 583 keV and 911 keV photopeaks of Tl^{208} and Ac^{228} respectively. The K^{40} concentration is determined from its 1460 keV photopeak. The counting time is 12000 s.

5 Results and Discussion

The gamma spectrometry results have shown that the radium content in the examined paints and in marble powder is under the detection limit (the detection limit is 1 Bq/kg). Only cement plaster contains radium in concentrations comparable with the concentrations in concrete. This may arise the exhalation of radon from a wall surface because cement plaster behaves as a source of radon. The concentrations of the other natural radionuclides in the examined samples are limited to some Bq/l.

The results of using cement plaster and marble powder on concrete slabs and bricks as well as the painting afterwards with the relief paint, the two types of emulsions and the epoxy paint are shown in Figure 1. In this figure the mean values of the radon exhalation from the samples before treatment and after each stage of treatment are presented. The total relative error (except the statistical error) is lower than 10 %. After covering with cement plaster the samples showed more exhalation than bare samples. This indicates that the cement plaster that contains radium is another source of radon activity indoors. On the othe hand the marble powder reduces the radon emanation from both materials.

It is significant to note that the paints do not reduce the radon exhalation to the same percentage when they are applied on different building materials. Figure 1 shows that the reduction in the exhalation after painting with the relief paint and the epoxy paint is higher for the brick than for the concrete slab. The low porosity and small diffusion length paints (epoxy paint and relief paint) are more effective on brick which has high porosity and long diffusion length. The results is in accordance with the theory (Savidoy A. et. al. 1996) that concerns the radon diffusion from a wall with a wall cover. The final formula that is given in the mentioned publication is:

$$\frac{J''}{J} = \frac{1}{\left(\frac{\varepsilon}{\varepsilon'} \cdot \frac{l}{l'} \cdot tnh\frac{L}{2 \cdot l} \cdot tnh\frac{d}{l'} + 1\right) \cdot cosh\frac{d}{l'}} \qquad (1)$$

where J″ is the emanation rate of radon after coating the concrete surface (Bq h^{-1}),

J is the emanation rate of radon from the bare concrete surface (Bq h^{-1}),

ε, ε' is the porosity of the concrete and of the cover respectively

l, l′ is the diffusion length of the concrete and of the cover respectively (m),

L is the thickness of the wall (m),

d is the thickness of the cover (m).

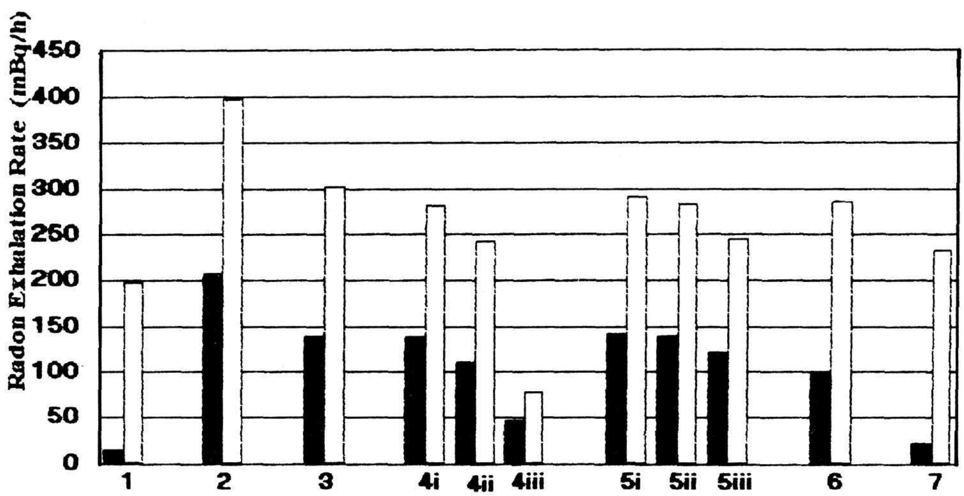

Figure 1. The experimental results of using cement plaster and marble powder on concrete slabs (pale color) and bricks (dark color) as well as the painting afterwards with the relief paint, the two types of emulsion and epoxy paint. 1: bare sample, 2: 1+two centimetres of cement plaster, 3: 2+one centimetre of marble powder, 4i-4ii-4iii: 3+one coat of emulsion primer and two, four and six coats of emulsion-acrylic, 5i-5ii-5iii: 3+one coat of emulsion primer and two, four and six coats of emulsion-PVA, 6: 3+one coat of emulsion primer and one coat of relief paint, 7: 3+one coat of epoxy primer and two coats of epoxy paint.

Also Figure 1 shows that between the two examined emulsions the one which has acrylic as binder is more effective.

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