SEASONAL VARIATION OF RADON CONCENTRATION - MEASUREMENTS IN SOME EUROPEAN COUNTRIES

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The radon concentrations in indoor air and in soil air vary both on short term (daily, weekly) and on long term (seasonal). The radon level and its changes depend on a few parameters, which may be different from one building to another and from one type of soil to another. It is important to know the seasonal variation of the indoor radon levels if the level is to be compared with the national upper limits in Europe for indoor radon concentrations. Also, the seasonal soil radon variation is important to know, especially if building regulations include demands on protection against entrance of soil radon into new constructed buildings.

The result of measurements of indoor radon and soil radon concentrations are discussed in the report. The measurements are made in and at houses, which are selected for long time studies of radon levels indoors and in the soil surrounding the houses. The houses are situated in countries in Europe with very different climate, building tradition and living habits of the inhabitants. The report emphasizes on the seasonal variation in the different countries of the radon concentrations both indoors and in the ground.

It is found that in countries with cold climate the indoor radon concentrations rise in the winter if the soil is the main source and the indoor concentrations are over 100 Bq/m³. It is also found that the radon levels in a house may be very individual from one time to another as a consequence of the habits of the inhabitants.

Concerning soil radon, studied in the investigation, the seasonal variation does not show any general pattern. There is however a tendency of a variation of a factor of two or more during the year of the soil radon concentration in a measuring point in the garden.

Key words: soil radon; indoor radon; seasonal variation; radon measurement

INTRODUCTION

There are many reasons for the variation of the indoor radon(²²₂Rn) concentration. If the building material is the source of the indoor radon the variation of the concentration mainly depends on the indoor air exchange rate especially in self-ventilated houses, that is in houses with no permanent mechanical ventilation. At air exchange rates far below 0,5 exchanges per hour the effect of the living habits of the inhabitants and of the outside weather conditions are obvious.
If the ground under the building is the main source of the indoor radon the underpressure inside the building relative the outside air is an additional parameter effecting the indoor radon concentration. This underpressure is for example caused by the temperature difference indoors versus outdoors in winter.

At measurements of indoor radon concentrations and the comparison with the national upper limit not only the length of the exposure time but also the time of the year are important. In order to decrease the effect of daily and weekly variations of the indoor radon concentration the length of the exposure time should be months. The time of the year should be when the inhabitants are expected to be mostly indoors although the radiation dose from radon then may be over-or underestimated depending on the source of the indoor radon gas.

In this report the results of long time measurements of indoor radon and soil radon concentrations are discussed. The measurements were made indoors in houses and in the ground close to houses. The houses were selected in a project for long time studies in order to learn more about the character of the radon gas [1-2].

METHODS AND TECHNIQUES

The houses, selected for the studies, are single unit houses situated in the area of Barcelona in Spain, of Kiel and Leipzig in Germany, of Montpellier in France and of Rome in Italy. This means not only differences in building techniques and living habits but also in climate. The reported examples of the studied radon variations are taken from indoor air measurements or soil air measurements. The technique of measurement is different at the five sites but the studies were made during at least two seasons. The soil radon measurements were all made at the depth of 70 cm or deeper. The detectors were placed in tubes, closed at the upper end.

Barcelona

Soil radon measurements were made during the period autumn to next summer with LR115- film in diffusion chamber [2-4]. In one series of measurement the soil radon concentrations at four different points around a house are compared. In another series the mean soil radon concentrations around three different houses are compared. The indoor radon levels of the houses are typical below 70 Bq/m³.

Kiel

The variation of the soil radon and the indoor radon concentrations for one single house was studied. The detectors used are based on LR115-film with the Lund cup model [5].

Montpellier

The variation of the indoor radon concentrations was studied in three different houses during one year using a detector based on LR115-film [2-4].

Rome

The soil radon concentrations were studied at different points around one house using an electronic detector [2-3, 6].
Leipzig

Indoor radon concentrations were studied in eleven houses during more than one year. During the same period the soil radon concentrations were measured around four different houses. The radon detector was of the type Altrac [2-3].

RESULTS

The result of the different measurements is given in Figures 1-5. The different Figures are discussed as follows:

Figure 1a shows the soil radon concentration at four different points of measurement around a house called AM in the Barcelona region. The concentration is averaged over one season. Point AM1 always gives the highest value. The concentration fluctuates during the year with a factor of two possibly with the lowest values in the summer (period 4).

Figure 1b shows the radon concentration in soil at three different houses called D1, DG and TZ in the Barcelona region. We observe, as at Figure 1a, that the concentration fluctuates during the year with a factor of two but with no common seasonal pattern.

Figure 2a shows the soil radon concentration at two points, 1 and 2, around a house in the Kiel region. No common seasonal pattern can be observed but the variation is also here about a factor of two. Figure 2b shows the indoor radon concentration in the house in five different rooms. Except during January the winter months December, February and November show a possible increase of the indoor radon concentration. The radon is coming from the ground.

Figure 3 shows the indoor radon concentrations in three different houses (A, B and C) in the Montpellier area during more than one year. House A and B have radon concentrations below 50 Bq/m³ while in house C the two measuring points may give values over 100 Bq/m³ in the winter. Anyhow there is a clear summer-winter effect.

Figure 4 shows how the soil radon concentration varies in six different points around a house. It is obvious that the concentration in some points is nearly constant during the whole period but varies in other points more than a factor of two. Besides, the general level is high in comparison with the levels shown in the other Figures.

Figure 5a gives the soil radon concentration at four houses in the Leipzig area. The concentration seems to vary also here with nearly a factor of two but without any clear pattern.

Figure 5b is also showing results from the Leipzig area. Indoor measurements in the eleven houses during more than one year reveal that two houses have problem with elevated radon levels in the winter-period. The summer period in 1995 gives generally lower concentrations than the summer period in 1996.
DISCUSSION AND CONCLUSION

Indoor radon

It may be expected that in countries with cold climate the indoor radon concentrations rise in the winter if the soil is the main source and the concentrations are over 100 Bq/m$^3$ [7]. This effect seems to be true in this investigation for the two series, presented in Figures 2b and 5b, where the soil is the main radon source and the ground may be frozen during some periods in the winter. The effect is however also present in the houses in Montpellier, which may be an effect of closing the windows in the winter [8].

The investigation also reveals that the radon levels in a house may be very individual from one time to another as a consequence of the habits of the inhabitants. These habits are very different in the north part of Europe from the habits in the south of Europe. As also the construction of buildings and the heating systems are different it is not likely to find common transport models predicting the indoor radon level from a certain soil radon pattern [8, 9].

Soil radon

The seasonal variation of the soil radon concentration does not show any general pattern. It was expected that in late winter time the radon concentration should be lowered because of higher ground water level. This is not the case generally in this study. It seems as if each measuring point has its own "radon life" although some points may be close to each other in a garden. Anyhow, there is a tendency of a variation of at least a factor of two during the year of the soil radon concentration in a measuring point.

In the Barcelona case (Figure 1a and 1b) the soil radon does not contribute very much to indoor radon levels, which are typically below 100 Bq/m$^3$. The reason is mainly the lack of indoor pressure generating mechanisms [9].

ACKNOWLEDGEMENT

Most data given in the report are from the EU-project ERB-CHRX-CT930422.

REFERENCES


Figure 1:  

a) Soil radon concentrations measured in four points (AM1-AM4) around a house in the Barcelona region. The periods 1-4 are the seasons from autumn 1995 to summer 1996. The errors are 10-20%.

b) Soil radon concentrations at three different houses D1, DG and TZ in the Barcelona region during the four seasons from autumn 1995 to summer 1996.
Figure 2: a) Soil radon concentrations measured at two different points around a house in the Kiel region during four periods. The errors are 10-20 %.
b) Indoor radon concentrations in the house in Kiel in five different rooms during more than one year. The errors are 10-20 %.
Figure 3: Indoor radon concentrations during more than one year in three different houses, A, B and C in the Montpellier region. Two point of measurements are given in house C.
Figure 4: The soil radon variation during the period from April to October 1995 at six different measuring points around houses in the Rome region. The errors are 10-20 %.
Figure 5  

a) Soil radon concentrations at four different sites in the Leipzig region during one year. The errors are 10-20 %.  
b) The indoor radon concentrations in eleven houses in the Leipzig region during one year. The errors are 10-20 %.