Concept of radon protection measures for new buildings in Germany

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ABSTRACT

In Germany, the radon concentration of 200 Bq/m^3 in accordance with the European recommendation (Kommission der Europäischen Gemeinschaften, 1990) is valid as design level for new buildings.

Radon from building material can make a significant contribution to the indoor concentration if industrial waste is used for its production. To avoid values above 200 Bq/m^3 due to the content of radium in building materials the use of several waste has been regulated by the Radiation Protection Ordinance (Ziegler, 2001).

However, in Germany the principal reason for enhanced indoor radon concentrations is the radon transport from building ground. Therefore, comprehensive investigations of the radon concentration in soil air and in houses were carried out to estimate radon transfer factors depending on the building type. It is considered to include the results of these investigations in a construction guideline about radon mitigation measures of existing buildings and radon protection of new buildings.

INDEX TERMS

Radon; Regulation; Prevention

INTRODUCTION

In Germany, the mean value of the radon concentration in dwellings is 50 Bq/m^3, with a variation between about 15 Bq/m^3 and more than 100 000 Bq/m^3. Taking into account different statistical approaches it can be assessed that 250 000–370 000 houses may have radon concentrations of more than 200 Bq/m^3.

Indoor radon is caused by radon exhalation from building materials and by radon transfer from the building ground. Radon from building material can make a significant contribution to the indoor concentration if industrial waste is used for its production. Therefore, the use of several residues is regulated by law in the Radiation Protection Ordinance.

Radon transfer from the ground into houses has beeen investigated to determine transfer factors depending on the building type. The transfer factors have been taken into account for the establishing of specific sealing measures against soil radon in a construction guideline. A basic idea for this guideline is the use of reasonable protection levels for new buildings, taking into account the current construction standards.

METHODS

Protection Against Radiation Exposure from Naturally Occurring Radionuclides in Building Materials

While the implementation of the European guidance Radiation Protection 112 ‘Radiological protection principles concerning the natural radioactivity of building materials’ (European Commission, 2000) is currently under discussion, the use of several by-products or waste for the construction of houses is regulated in the new Radiation Protection Ordinance since July 2001.

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In Germany, the materials of concern listed in Table 1 must be subject to supervision if their re-use or disposal may lead to an exposure to members of the public to more than 1 mSv. They may be released from supervision only in the case if the above mentioned dose value will not be exceeded.

Table 1 Supervision-needing relics (Ziegler, 2001)

No.	Waste.
1	Sludges and deposits from the extraction of oil and gas
2	Not prepared phosphorgypsum, sludges from their preparation and slags form the milling of crude phosphate (phosphorite)
3	Adjoining rock, sludges, sand, slags and dusts from: The exploitation and milling of bauxite, columbite, pyrochlore, microlite, euxenite, copper shale, ores of tin, rare earths and uranium The recycling of concentrates and relics wich are obtained at the exploitation and milling of these ores and minerals Minerals corresponding to the above-mentioned ores, obtained at the exploitation and milling of other raw materials
4	Dusts and sludges resulting from the cleaning of fumes or at the primary smelting in the metallurgy of pig iron and non-iron

The residues are outside the scope of the law if the specific activity of each radionuclide of the U-238 and Th-232 decay chain in the residues is lower than 0.2 Bq/g.

The residues do not require supervision if in case their use is

$$C_{U238max} + C_{Th232max} = C \quad \text{with the supervision level } C = 1 \text{ Bq/g}$$

The level $C = 0.5$ Bq/g has to be observed for house construction materials if the share of these residues is more than 20%.

Protection Against Radon Entry from the Building Ground

During the last 10 years, the relationship between the radon concentration in soil gas, the type of construction and the indoor radon concentration has been investigated by Kemski & Partner and the Geological Institut of the University Bonn in several research projects. More than 2600 sites, distributed country-wide, have been investigated for both radon concentration in soil gas and in houses. The depth of sampling of soil air was 1 m. The indoor measurements were carried out over 1 year with track etch detectors in one basement room and in a living room on the ground floor.

Figure 1 shows some probability plots using results of living rooms in family houses with a cellar, concrete construction of both, floor and ceiling and no natural building materials like quarried stones. This construction is typical in Germany and will be called ‘reference room’. The mean transfer factors (quotient of radon concentration indoors to soil air) for all investigated basement rooms can be given by 2.1‰ and for all ground floor rooms by 1.4‰ (Kemski *et al.*, 2002). The median transfer factor for the reference room is 1.0‰.

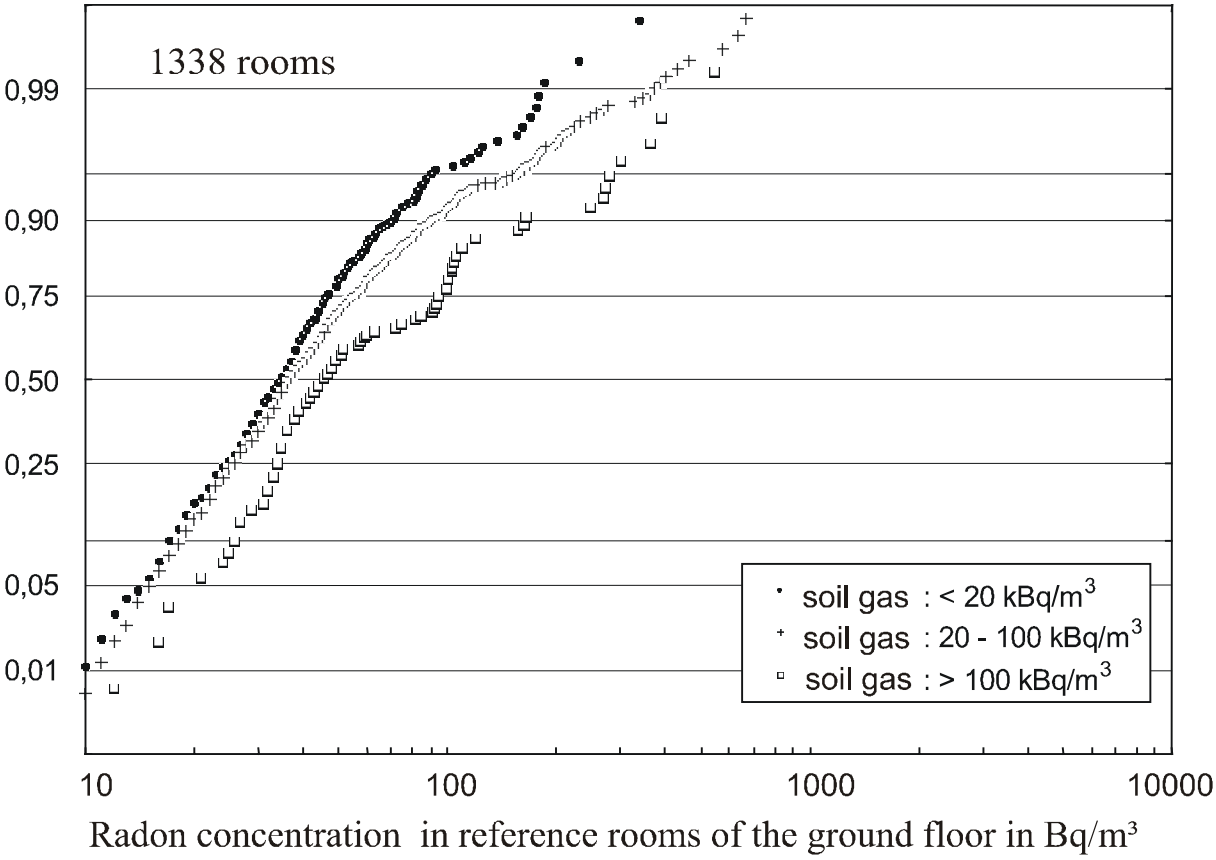

Figure 1 Probability plot of the radon concentration in ground floor in dependency on the radon concentration in soil air (Kemski & Partner).

On the basis of these results we propose the following approach for the above mentioned construction guideline:

- For building sites with radon concentrations in soil gas <20 kBq/m^3 the indoor radon concentration will probably not exceed the European design value, taking into account the common construction type. This applies to approximately 38% of the total area of Germany.
- For building sites with radon concentrations in soil gas between 20 and 100 kBq/m^3 a continuous, reinforced 15-cm-thick concrete slab combined with the application of a well designed protection against soil humidity is usually a sufficient protection against the entry of soil radon (58% of the area).
- If radon in soil gas exceeds 100 kBq/m^3 (approximately 4% of the area), additional measures like drainage have to be considered.

Figure 2 gives an small scaled map about the radon concentration in soil air in Germany. The map can be used only as a general survey. In the end the local authorities must decide on the necessity and kind of measures taken at the specific construction sides, taking into account their detailed knowledge about the geology and results of indoor radon measurements in the area of interest.

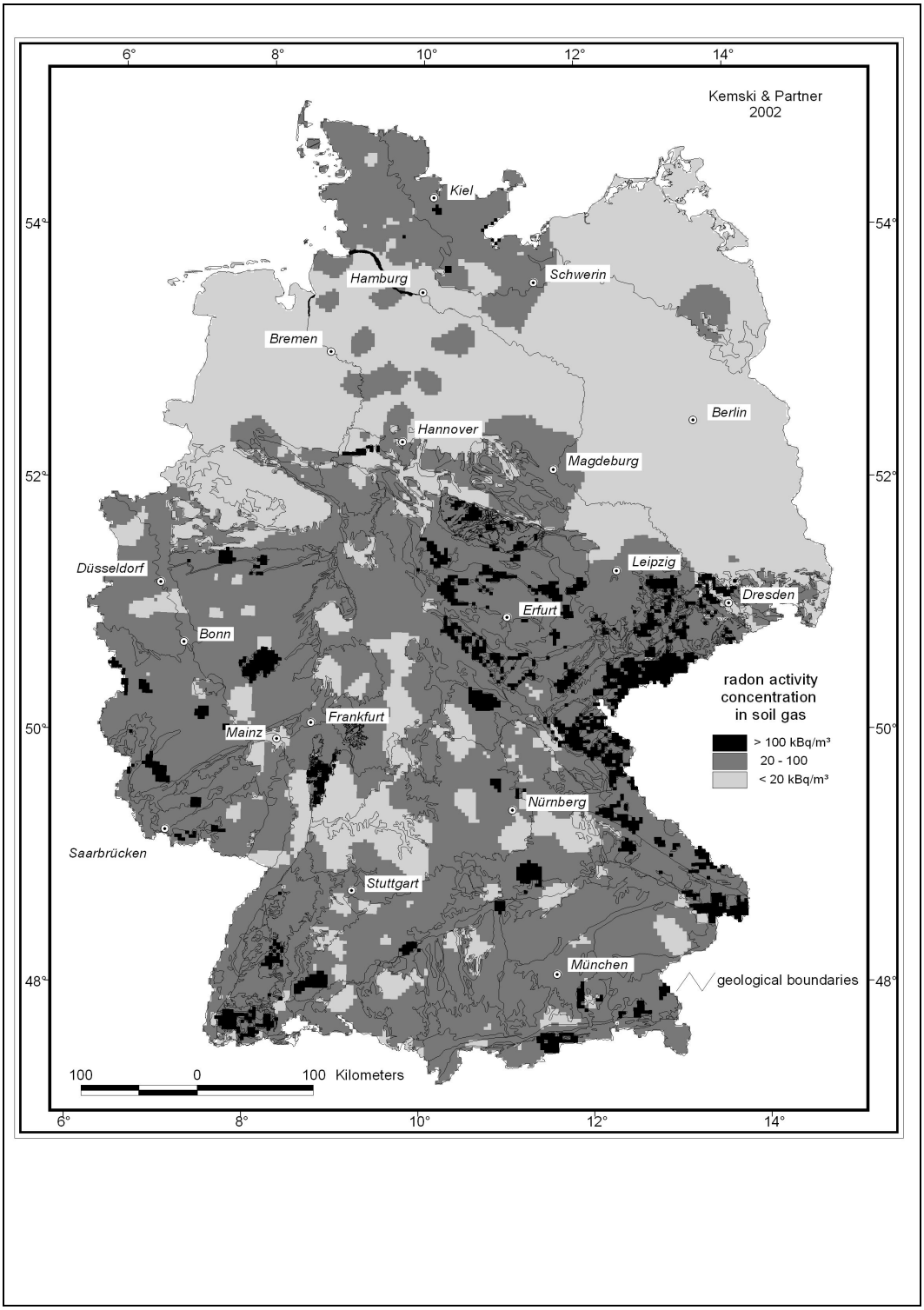

Figure 2 Radon concetration in soil air at the depth of 1 m.

DISCUSSION

The regulations about the use of waste for construction purposes are in agreement with the European Construction Products Directive (Lutz and Springborn, 2000) and are suitable to limit the radon concentration in buildings.

The most important source for enhanced indoor radon concentrations in Germany is the soil gas. Therefore, protection measures against soil radon for new houses and mitigation

techniques for old houses are the focus of a construction guideline. Basic research showed that no special protection has to be recommended in about 38% of the whole area of Germany. In the remaining 62% of the area, special protection systems should be used depending on the soil gas radon concentration.

On account of the very low probability to meet an increased indoor radon concentration in a new building of nearly the whole northern part of Germany, it would not be reasonable to spend money for a site survey. In areas with an enhanced radon potential of the ground the benefit of soil gas measurements depends on the costs of a reliable protection system, as it is explained in the 'German Radon Handbook' (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit; Bundesamt für Strahlenschutz, 2001). The measures strain the financial budget of the builders not more than necessary, because they take into account today's customary construction principles.

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