

## RADON CONCENTRATION LEVELS IN HOMES IN THE FEDERAL REPUBLIC OF GERMANY

Andreas Wicke  
Institut für Strahlenhygiene des Bundesgesundheitsamtes  
Neuherberg

Manfred Urban and Hans Kiefer  
Hauptabteilung Sicherheit, Kernforschungszentrum Karlsruhe

### ABSTRACT

A large-scale radon survey is presently carried out in the Federal Republic of Germany using time-integrating radon dosimeters. Based on measurements in 4512 homes the distribution of the radon concentration levels fairly well exhibits a log-normal form with a median value of  $42 \text{ Bq/m}^3$ .

Significant parameters influencing the radon level indoors are the type of housing and the geological environment. Highest radon concentration levels are found in detached houses with direct ground contact.

### INTRODUCTION

Natural radon in air is expected to be one of the most important contributors to the radiation exposure of the general population. Major sources of radon are the ground and - in structures - the building material. In some cases natural gas for cooking and heating and the use of radon-rich tap water may release substantial amounts of radon into indoor space. In normal, naturally ventilated houses with stone walls the radon concentration is expected to be about a factor of 2 to 5 higher than in free air near ground level.

Depending on location, geology, weather conditions, ventilation of the house and living habits of the people, the concentration of radon may change substantially with time and place (Wi83).

In order to obtain representative annual exposure data for the general population time-integrating measurements at many locations are necessary. In this paper the nation-wide radon survey program is outlined and some of the most important results are presented.

### METHOD AND ORGANIZATION

For the purpose of long-term integrated measurements of radon, a purely passive radon dosimeter is employed in this study (Ur81). The instrument consists of a small diffusion chamber with a nuclear track detector (Polycarbonate). After exposure the detector foil is removed from the cup and electrochemically etched. Track counting is done visually. Calibration at standard radon atmosphere was repeated several times by different laboratories. Reproducibility, fading characteristics, mechanical stability and low price make the system advantageous for long-term large-scale measurements.

To organize the distribution and recollection of the radon dosimeters, nine laboratories in different parts of Germany are involved in the survey. In order to achieve an adequate distribution of the instruments, cooperation with the local administration of towns and counties turned out to be very effective. Different housing densities in various regions of Germany have been taken into account.

For the general survey each selected home was provided with two dosimeters, one of each was placed in the living room and one in the bedroom. After three months of exposure both dosimeters are returned to the laboratory together with a questionnaire.

Electrochemical etching and the evaluation of the radon concentration was performed by Hauptabteilung Sicherheit, Kernforschungszentrum Karlsruhe, data collection and the electronic data processing was done by the Institut für Strahlenhygiene, Neuherberg. According to our plan, more than 5 000 homes will be surveyed by the end of 1983.

## RESULTS

Complete results have been obtained from 4 512 homes. The distribution of the radon levels are approximately log-normal with 90 % of the dwellings having radon concentrations of less than  $80 \text{ Bq/m}^3$  (Fig. 1). The median value is close to  $42 \text{ Bq/m}^3$ , the geometric standard deviation 1.7.

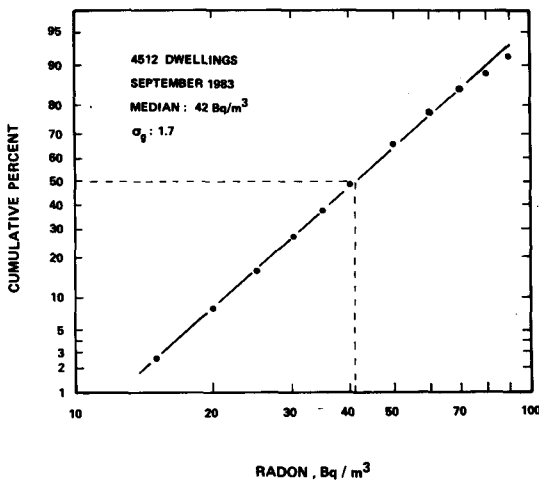


Fig. 1: Distribution of the radon concentration levels indoors

According to Fig. 2 the calculated median radon concentration is significantly higher for detached houses ( $45 \text{ Bq/m}^3$ ) compared with multi-family houses ( $36 \text{ Bq/m}^3$ ) and high-rise buildings ( $33 \text{ Bq/m}^3$ ). The two main probable explanations for this observation are that detached houses have lower ventilation rates and are easier exposed to radon from the ground.

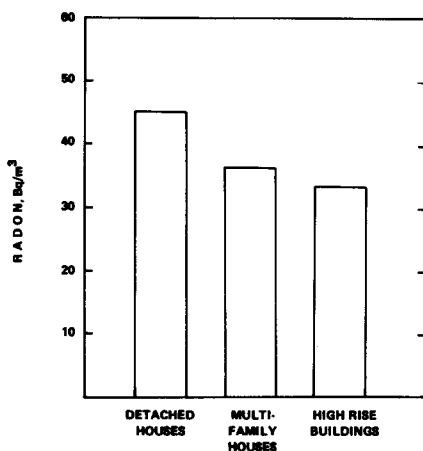


Fig. 2 : Median radon concentration levels in different types of houses

This fact is also reflected in Fig. 3. Highest radon concentrations are found in homes with direct ground contact. Apartments on upper floors show a decreasing radon level with increasing distance from the ground.

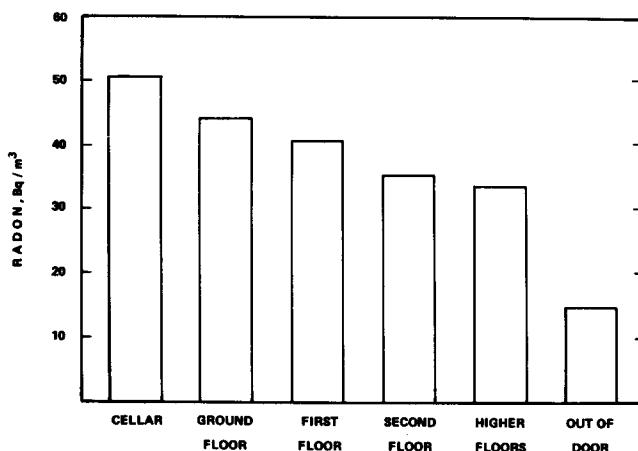
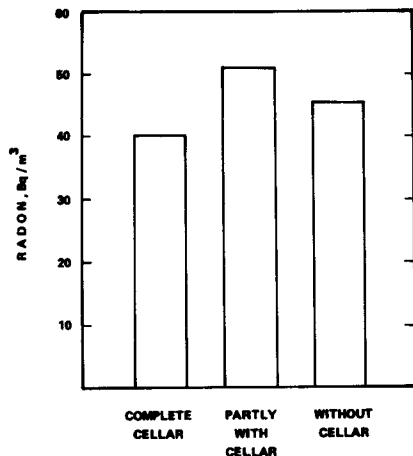


Fig. 3 : Median radon concentration levels indoors depending on different distances from the ground

The importance of different types of foundations of a building is demonstrated in Fig. 4. The most frequent type of house built in Germany has a complete basement. Such a house has a median radon concentration of  $40 \text{ Bq/m}^3$ , while houses without or partial basements show elevated levels,  $45 \text{ Bq/m}^3$  and  $51 \text{ Bq/m}^3$ , respectively.



**Fig. 4:** Median radon concentrations in houses with different types of basements

The different types of houses might also be responsible for the fact that relatively low levels of radon are observed in big cities, such as Hamburg, Munich, Frankfurt or Berlin, in contrast to higher values present in rural areas. In addition, high radon levels are expected in houses located in certain granite areas. Those "regional" studies are still in progress.

#### ACKNOWLEDGEMENTS

The authors gratefully acknowledge the assistance of the following institutions: Kernforschungsanlage Jülich, GKSS-Forschungszentrum Geesthacht, Universität Göttingen, Gießen and Homburg, Physikalisch-Technische Bundesanstalt Braunschweig and Staatliches Materialprüfungsamt Dortmund.

This contribution was prepared as an account of work sponsored by the Federal Ministry of Interior of the Federal Republic of Germany. The views and opinions of the authors expressed herein do not necessarily state or reflect those of the Federal Minister of Interior.

#### REFERENCES

- (Ur 81) Urban, M., Piesch, E. (1981): Low level environmental radon dosimetry with a passive track etch detector device. Rad. Prot. Dosimetry 1, 97-109.
- (Wi 83) Wicke, A. (1983): Exposure of the population to radon daughters - problems associated with the assessment of the annual dose. Paper presented at the INTERNATIONAL SEMINAR ON INDOOR EXPOSURE TO NATURAL RADIATION AND RELATED RISK ASSESSMENT, Capri, Italy, October 3-5, 1983.