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Experiences from a high radon area in Norway

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In 1988, very high levels of radon were detected in a kindergarden in Kinsarvik, a village by the Hardanger Fjord at the west coast of Norway. In 1996-97, an extensive radon measurement and mitigation project was carried out. The radon measurement results revealed that most buildings in this area had very high or extremely high radon concentrations.

Radon measurements and mitigation 1996-1997
When the seriousness of the problem was recognized, a mitigation project was initiated. It was organized with a steering group of local political leaders and representatives of the public. A working group with representatives from the local administration and health personnel, in addition to various radon experts, was set up. In the first phase of the project, measurements were carried out in most dwellings in the area.

About 60 % of the alpha track detectors were overexposed, and had to be analyzed by a special procedure. Annual average radon concentrations up to 56.000 Bq/m^3 were found, and the mean radon concentration was 4340 Bq/m^3. Published values of radiation doses to the population ranged from 3.6 to 920 mSv/year, with a mean value of 72 mSv/year. These dose estimates values were calculated based on the earlier ICRP risk-based approach developed in ICRP 65 in the calculation of effective dose (Sundal et al, 2007).

Measurements had to be carried out in all four seasons due to extreme and unusual seasonal variations. Normally, radon concentrations in dwellings are highest in the cold winter season. In Kinsarvik, the radon concentrations are highest in summer in the lower part of the residential area, and highest in winter in the upper part. This is due to the particular geological conditions, with highly permeable masses covered by more fine-grained sediments (Sundal et al 2008).

A pilot project for radon reduction techniques were performed in 3 of the most severely affected houses. Radon levels were reduced in these houses, but were still too high. Mitigation plans were developed for 96 houses, and in the period 1999- 2003 economic compensation for the mitigations were made available.

Stakeholders
The major stakeholders include national and local authorities, the public (homeowners, workers) and local industry and employers. Furthermore, primary health care workers and teachers could be important as secondary informants on radon health risks and how the risk can be reduced.

Response of the public
Despite intense information efforts, most homeowners did not act to mitigate their homes. Interest and anxiety varied considerably. Many compared their radon values with other houses

nearby, or with the very worst affected in the area. Hence, levels of a few thousand Bq/m^3 could be perceived as moderate levels in relation to this. Many, especially elderly persons, did not believe in the health risks, and referred to the fact that people have inhabited these areas for centuries. Anxiety was, however, clearly age dependent, and parents were particularly concerned with their children's health.

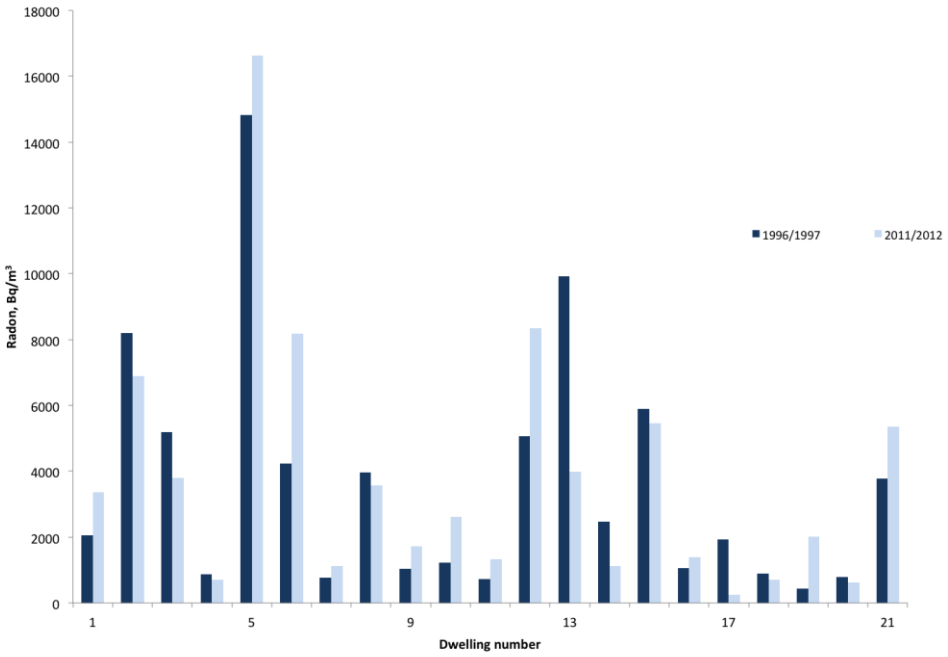

Fig. 1 - Annual mean radon concentrations in dwellings 1996/97 compared with 2011/12

Recently, new radon measurements have been carried out, and the result shows no significant overall reductions when compared with the measurements made approximately 15 years ago. This is of course a serious concern, and in the new National Radon Strategy (2009) areas with extremely high radon levels have been given special attention.

Exposure situations

High radon concentrations affect all types of buildings in the area: dwellings, school, kindergarden, workplaces, health care institutions, shops and other public buildings. Even the outdoor radon concentrations are exceptionally high, and could even exceed an annual average of 200 Bq/m^3 (Jensen et al, 2006). Children are being exposed to high levels both at home and at school, and it may be assumed that a large fraction of local workers have their homes in the affected area. This raises the question of whether it is reasonable to view the radon problem in the area as separate exposure situations depending on whether the building in question is a home, a school or a workplace.

Some lessons learned

It is essential that the local authorities and the public are involved in the planning and implementation of the radon reduction projects.

In many cases it was technically difficult to achieve indoor radon levels below the action limit at the time (200 Bq/m^3). In such cases, the efforts were perceived as unsuccessful, even when radon was reduced by more than 70-90 %. Homeowners were therefore in some cases

reluctant to carry out the mitigation. It is therefore important to encourage any reductions of radon.

It is important to encourage mitigation shortly after information and measurement campaigns. If not, it seems that the motivation to mitigate decreases with time.

Most primary health care workers have limited knowledge on radon risks and the synergy with smoking. In areas where such high radon levels occur, it is particularly important that correct advice on both smoking and radon is given by the primary health services. Some individuals have been exposed to high radiation doses, and need detailed advice regarding their situation.

References

1. Jensen CL, Sundal AV, Ånestad K, *Radon concentrations in outdoor air. Presentation of results from radon measurements in outdoor air in six selected Norwegian areas.* StrålevernRapport 2006:20. Østerås: Norwegian Radiation protection Authority, 2006 (In Norwegian)

2. *Strategy for reduction of radon exposure in Norway* (2009) http://www.nrpa.no/dav/000c3a1385.pdf

3. Sundal AV, Jensen CL, Ånestad K, Strand T. *Anomalously high radon concentrations in dwellings located on permeable glacial sediments*. J Radiol Prot. 2007; 27:287-98

Fig. 2 - Kinsarvik located at the mouth of the Sørfjorden and the Eidfjorden where it branches from the Hardangerfjord, county of Hordaland, Norway.