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The Radon Situation in Sweden

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Summary:
In July 2004 the Swedish government set new detection limits of 200Bq/m³ for private real estate and public buildings. This was done to reduce the risk of lung cancer in the population and in correspondence to the national goal of having measured and reduced the indoor radon level for residential buildings by the year 2020. Two big surveys investigating radon levels in Sweden have been done in the last 20 years, ELIB and the Radon Investigation.

The first survey was within the research program *Power Consumption in populated areas (ELIB)*. The second survey was done between October 1991 and May 1992 and included 1360 residents where 714 were small houses and 646 were apartments built before 1988.

These residents were selected based on the level of urbanisation and the temperature zone in which they were located. The estimated distribution within each community was taken into account as was the cost of mitigation.

These residents were selected in areas well geographically distributed to cover both countryside and big cities.

Referring to the national library of registered residents, 60% of all residents live in small houses. Within ELIB they concluded that since the size of apartments varied more than the size of small houses it was therefore better to measure a proportionally larger amount of apartments. These measurements were done with alpha track detectors housed in electrically conductive plastic material. The Swedish Radiation Protection Institute (SSI) was responsible for the measurements using a design of detectors developed by collaboration between SSI and NRPB (National Radiation Protection Board).

The second survey, *Radon Survey,* was performed by a written survey to all municipalities in Sweden during the year 2000. The survey included questions about the radon level in houses including residential, schools, retirement homes and as well as radon levels in drinking water. In the survey they asked for measurements that had been paid by the municipality, by an appointed partner, or measurements that have been ordered through the municipality from the owners or residents. This survey gave a total of 215 000 measurements performed in small houses, corresponding to approximately 12% of the total number of small houses, and 44 200 apartments, corresponding to approximately 2.2% of the total number.

The ELIB survey concluded that 16-18% of all small houses and 5-8% of apartments have a radon level higher than 200 Bq/m³, see table 1. Another remarkable conclusion is that the radon values have been lowered by 30% for small houses and 15% for apartments built after the introduction of radon limits as compared to older buildings. This may in part be to the ageing process in the older houses which is a difficult effect to estimate. If the effect of radioactive concrete (Blue concrete) is included then we find that the average has been lowered by 50%. The use of this material has increased the average radon value of all houses by approximately 10% for small houses and 20% for apartments. In the Radon Survey they found that 35% all residents with small houses have radon levels above 200Bq/m³. For Apartment residents the study found that 28% of the monitored apartments had a level that exceeded 200Bq/m³. This is much higher than what was concluded in the ELIB survey. The difference in radon level between the ELIB survey and the *Radon Survey* may be in part due to the fact that the municipalities have concentrated their measurements to buildings that included radioactive building material or are located in high risk areas (radon levels higher than 50kBq/m3 in soil at 1 m depth).

ELIB*	Small houses (Bq/m³)	Apartment residents (Bq/m³)
Mean value	141	75
Building year: -1980/ 1981-	109 / 77	48 / 42
South of Sweden	60	32
Middle of Sweden	121	63
North of Sweden	99	41
Radioactive building blocks	134	61
Not ---"---	52	29
Crawlspace foundation	72	
Slab-on-grade foundation	101	
Basement	106	
Ground floor		85
Above ground floor		63
Natural ventilation (-1980/1981-)	105/77	57/48
Negative pressure ventilation(-1980/1981-)	97/77	46/48
Balanced flow ventilation (-1980/1981-)	78/78	32/42
Result above 200 Bq/m³ :	16-18%	5-8%
Final conclusion of the Radon Survey		
Result above 200 Bq/m³:	35%	28%

* The radon results have been weighted with the inverse of the accuracy of the selection
Table 1: Radon Levels in residents refer to ELIB and the Radon Survey.

In the ELIB survey they used a statistical method for the selection of data in order to derive the number of houses and residents that are exposed to a certain level of radon, see figure 1. Based on this data a hypothetical distribution was used to estimate the number of residents with higher levels, the data from the survey was not by itself enough for such an estimation. This estimation (for levels higher than 400Bq/m³) gave 4-7% and 0.8-4% for small houses and apartment residents respectively. Accordingly numbers for residents above 800Bq/m³ were found to be 0.7-2% and 0.1-1%. According to this data higher radon levels are twice as likely for small houses compared to apartments.

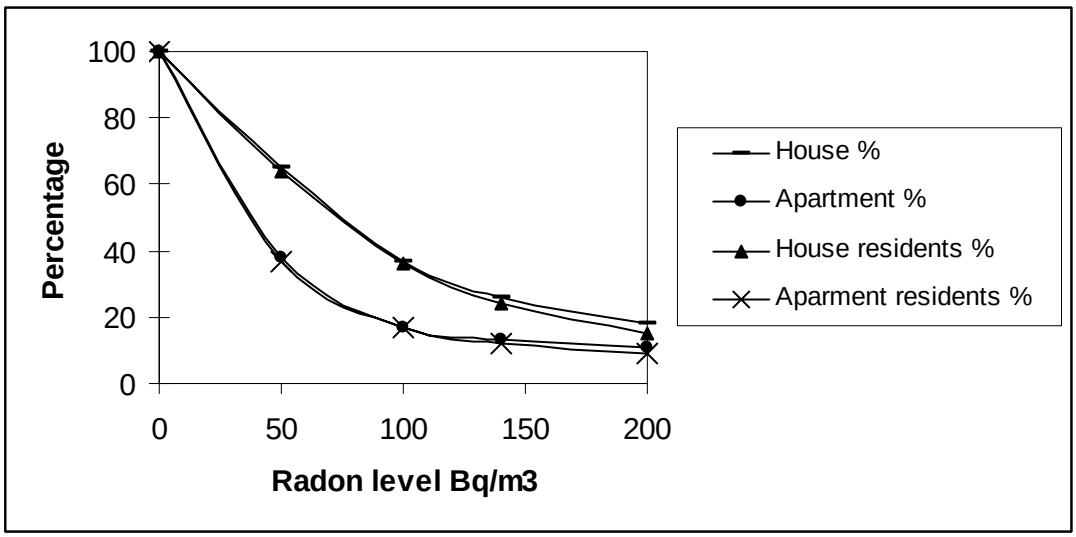

Figure 1: Number of residents that, according to ELIB, are exposed to radon.

Another interesting investigation made in the *Radon Survey* was to study the radon value in so called high and low risk areas. They found that the percentage of houses with levels above 200Bq/m^3 in high risk areas was 33% compared with 20-22.5% in areas with medium or low risk The difference between high and the rest was noticeable but not big enough to make general conclusions of where and when you should measure. Measurements in houses built after 1980 where they found 16% have a level above 200Bq/m^3 in high risk areas and 9-12% in low risk areas support this conclusion. In Hudiksvall all buildings built since 1980 have been measured. Here the difference between risk classification and radon level was practically nonexistent as in all cases 10-14% of the houses were found to be above the limit. This justifies ELIBs conclusion that although radon levels in houses built after 1980 are lower than in older ones, still the modern construction companies do not always follow the rules for radon proof constructions.

In summary, one can mention that radon exists frequently in both types of residents, but it is a bigger problem for residents of small houses compared with apartments. The use of radioactive building materials have a greater effect on the radon level in the house than the location relative to so called high or low risk areas for radon in soil. The big difference between the result generated by the ELIB investigation and the *Radon Survey* is perhaps not entirely explained by the non-randomized way of selection of residents used in the *Radon survey*. Another important reason can be that ELIB is based on 1360 residents and that the radon situation for the whole country has been extracted using a calculation of probability which includes several factors such as the temperature zone and proportion of that housing type. The limited number of measurements is illustrated by the fact that number of houses including radioactive building material is only 42.

To clarify the radon situation in the residents of today, regarding the national average and regional distribution, it has been decided that a new survey needs to be done. This study will make it possible to better present the risk of lung cancer associated to radon exposure. This decision was made by Ministry of Residents, The National Board of Social matters and the Swedish institute of Radiation protection. This survey will be done by the Environmental Medical Centre in the west region of Gotaland (VMC) and Gothenburg University. So far measurements have only been done in the community of Skövde.

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