RADON IN SWEDISH DWELLINGS

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Radon and its daughter products are an urgent problem in Sweden. Factors expected to have an effect on the radiation dose to the population are the building materials in the existing houses, changes in the building techniques and in the building regulations.

Since the energy crisis, major efforts have been made to decrease the consumption of energy. A large saving can be achieved in the heating of houses, for instance, by decreasing the ventilation rate. Such measures will cause a greater problem in Sweden than in other countries both because of the cold climate and because about 10 percent of the existing dwellings contain the building material aerated concrete based on alum shale. Production of this material ceased in 1975.

The variations of the radon concentrations have been investigated in typical houses. The concentrations of radon and daughter products, the air changes and the gamma levels have been investigated in 63 dwellings in seven types of houses built at the beginning of the 1970s in the town Gävle in central Sweden (1). The results are shown in the table. Correction factors for normal airing, occupancy time, etc., have been applied before calculating the radiation doses.

These results together with results from investigations of the activity concentration in building materials, the gamma radiation in dwellings and the frequency of various ventilation systems and building materials have been used to calculate the absorbed dose in the basal cells of bronchial epithelium in the lung for various periods.

For houses built at the beginning of the 1970s the average radiation dose has been calculated to be about 6 mGy/y (0.6 rad/y) and for houses built before 1946 investigated by Hultqvist (2) to be about 1.5 mGy/y (0.15 rad/y). For houses built after 1975 the radiation dose can be expected to be 4 mGy/y (0.4 rad/y). For dwellings existing in 1976 the radiation dose can be estimated to be 3.5 mGy/y (0.35 rad/y). This implies an enhancement of the collective dose in the basal cells of bronchial epithelium in the lung from the 1940s to the middle of the 1970s by 2×10^4 manGy/y (2×10^6 manrad/y) from radon and daughter products in the Swedish population.

Only the doses from radon originating from the building materials and the ground are considered. The appreciable contributions from radon in tap water in some areas are being investigated and will be reported later.

Intensive efforts to develop new technical solutions for the heating and ventilation systems are in progress. Many of these imply recirculation of the air with a minimum addition of fresh air. Some technical solutions under certain circumstances may cause substantially increased radon concentrations. This is now being investigated.

Group No.	Building materials in the walls and vent. system[a)]	Air exchanges per hour		Radon Bq/m^3 I	Radon Bq/m^3 II	Radon daught. Bq/m^3 I	Radon daught. Bq/m^3 II
MULTI-FAMILY HOUSES							
1	concrete, F	0.3-0.6	low.	59	48	22	11
			aver.	170	140	70	52
			high.	590	780	260	310
2	concrete + sand-based aerated concrete, F	0.5-0.9	low.	37	26	13	9
			aver.	89	85	31	23
			high.	150	140	48	41
3	concrete + sand-based and alum shale based aerated concrete, F	0.4-0.8	low.	74	93	22	11
			aver.	180	160	52	44
			high.	440	410	150	140
SINGLE-FAMILY HOUSES							
4	facade brick (sandstone), wood construction, F	0.4-0.7	low.	n		8	
			aver.	56		22	
			high.	140		38	
5	wood, the cellar of alum shale based aerated concrete, F	0.4-0.7	low.	n		4	
			aver.	200		81	
			high.	370		140	
	do. without cellar	0.8	low.	100		33	
			aver.	100		37	
			high.	100		41	
6	alum shale based aerated concrete, S	0.2-0.5	low.	150		67	
			aver.	270		120	
			high.	410		190	
7	facade brick (clay), wood construction, S	0.1-0.2	low.	220		82	
			aver.	410		170	
			high.	560		310	

1 Bq/m^3 $\simeq$ 0.027 pCi/l
I and II mean the first and second phases between which the ventilation systems were adjusted.
n $\leq$ minimum detectable value, 26 Bq/m^3 for radon.
a) F = mechanical exhaust ventilation system, S = natural draught ventilation system, in the studied houses with fan over kitchen stove.

References

1. Eriksson, B., B. Lofstedt, G.A. Swedjemark, and B. Hakansson (1976). Requirements for the ventilation in single-family and multi-family houses. Bull. SIB 17:1976, National Swedish Institute for Building Research.

2. Hultqvist, B. (1956). Studies on naturally occurring ionizing radiations, Kgl. Svenska Vetenskapsakad. Handl. Ser. 4, Band 6, No. 3, Stockholm.