RADON IN SHOW CAVES, VISITOR MINES, AND SPAS OF NORTHRHINE-WESTPHALIA

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ABSTRACT

Radon levels were measured in all show caves, visitor mines and thermal spas of Northrhine-Westphalia. Long-term measurements were performed by a passive time-integrating method using diffusion type dosemeter with nuclear track detector. Radon-222 concentrations up to 12000 Bq m^{-3} were found. Instantaneous measurements of Rn-222 were taken with Lucascells and a portable radon monitor. Decay products were determined via dust filter sampling followed by alpha spectrometry. Equilibrium factors ranged between 0.34 and 0.80.

INTRODUCTION

It is well recognized that the major contribution to the annual average dose received by man has its origin in natural radiation. About half of the effective dose equivalent is due to inhalation of radon and its decay products. Whereas radon concentrations have been measured continuously in almost all West-German coal mines for over 10 years now [1], there has been a lack of such data concerning the visitor mines, show caves and thermal spas where the annual effective dose equivalent may exceed the governmental limits for occupational radiation exposure.

METHODS AND INSTRUMENTS

For long-term Rn-222 determination diffusion cells of the so-called Karlsruhe-type have been used, equipped with cellulose nitrate nuclear track detectors (KODAK, type LR 115 II). The cells were protected against dust and humidity by silicone coated glass fiber filters. 5 to 10 dosemeters were installed along the visitors pathway in each cave or mine. Exposure time ranged from 60 to 90 days depending on radon concentrations. After etching the detectors were analyzed by automatic microscopic image analysis.

Instantaneous radon concentrations were measured using a radon monitor (Atmos-12 by ALNOR) with ionization chamber and/or with Lucas cells of 100 ml volume.
Radon daughter products have been accumulated on membrane filters and determined by alpha spectrometry using a portable surface barrier detector spectrometer.

RESULTS

Table 1 contains the maxima, minima and mean values of all measurements, the equilibrium factors F, and the resulting annual effective equivalent doses. In cases where the radon progeny had not been measured an equilibrium factor of 50 % has been assumed. The effective equivalent doses have been calculated according to the following equation and assumptions:

$$D = A \cdot V \cdot t \cdot F \cdot C_D \quad / \quad mSv\ a^{-1}$$

A: activity concentration / Bq m^{-3}

V: breething rate / 1,2 $m^3\ h^{-1}$

t: annual working time / 1600 h

F: equilibrium factor

C_D: dose conversion factor / $1,25 \cdot 10^{-5}$ mSv Bq^{-1} *)

Some of the annual effective equivalent doses are close to or above the annual limit of 50 mSv for occupational radiation exposure. In these cases it was necessary to reduce the individual working time.

In Fig. 1 the frequency distribution of the radon concentrations in the show caves and visitor mines is shown. Five percent of all values are above 5000 Bq m^{-3}.
Fig. 2 shows the radon concentration over time for one cave, exhibiting a distinct minimum during the winter season.

REFERENCES

1. Rox, A., Fahland, J., Freder, R., Herzog, W., 1991, Bestimmung von Radon und seinen Folgeprodukten im Steinkohlebergbau, publication series Progress in Radiation Protection, FS-91-56-T, p. 57-73, ISSN 1013-4506

*) According to the German *"Strahlenschutzverordnung"*

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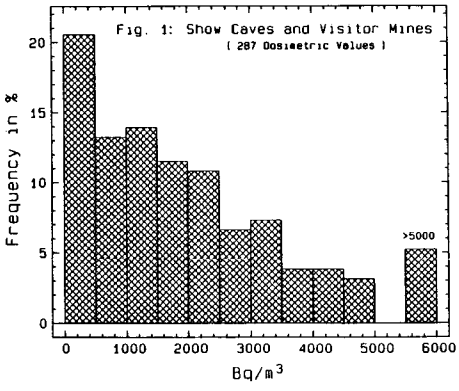

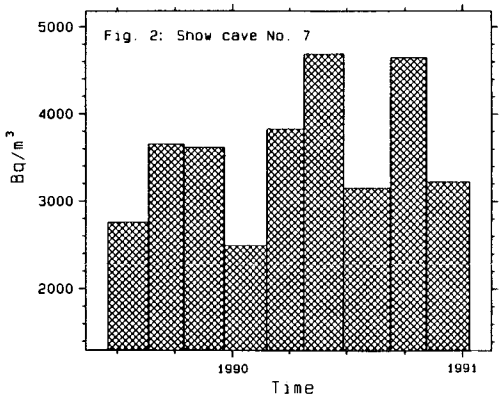

Table 1:

No.	Lucas Cell (Bq/m^3) Minimum	Maximum	Mean	Dosemeter (Bq/m^3) Minimum	Maximum	Mean	F (%)	mSv/a
1	239	2030	687	114	2916	1153	51.0	14.1
2	1698	3341	2431	144	2616	1197	39.4	11.3
3	38	74	56	46	46	46	47.5	0.5
4	1788	8677	4342	382	4106	1748	44.1	18.5
5	80	508	213	180	359	254	53.5	3.3
6	322	531	452	327	2086	1133	50.0 *	13.6
7	3791	5861	4815	1698	4779	3145	53.1	40.1
8	475	1431	957	59	489	203	65.9	3.2
9	941	5066	2330	907	3916	2307	58.5	32.4
10	630	4929	2730	2337	5359	3521	40.9	34.6
11	65	12398	3953	2820	8822	6697	60.6	97.5
12	99	100	100	81	81	81	33.6	0.7
13	80	635	162	155	1583	907	69.9	15.2
14	192	504	384	2757	3162	3018	50.0 *	36.2
15	147	152	148	732	732	732	50.0 *	8.8
16	73	95	76	164	241	195	50.0 *	2.3
17	20	35	27	320	493	407	50.0 *	4.9
18	1405	1555	1472	2544	6027	4238	79.8	81.2
19	1	7	3	1	128	37	50.0 *	0.4
20	7	9	8	19	19	19	50.0 *	0.2
21	6	146	53	344	344	344	50.0 *	4.1
22	118	859	291	19	1026	265	50.0 *	3.2
23	3	2120	437	47	838	334	50.0 *	4.0
24	5	31	14	31	103	167	50.0 *	2.0

*) assumed value

No. 1 - 9 : Show Caves
No. 10 - 18 : Visitor Mines
No. 19 - 24 : Spas