INDOOR RADON LEVELS IN A PUBLIC SCHOOL AND SOME DWELLINGS FROM THE VILLAGE OF TEIÀ, CATALONIA (SPAIN).

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INTRODUCTION

The radiation dose from inhaled decay products of radon (^{222}Rn) is the dominant component of radiation exposure of the general population (1). Due to the fact that children are more sensitive to radiation than adults, it is of interest to determine the indoor radon levels at which they are exposed to. The determination of radon levels in schools is important because children spend there an important fraction of their time. In this paper we present the indoor radon levels measured in a public school and in some of the houses where pupils inhabit. This study was carried out during winter in the village of Teià,, situated at 20 km far from Barcelona, which has only one public school and where the soil is composed mainly of granite rock. Moreover, an estimation of the upper limit of the annual effective radiation dose received by pupils is given.

EXPERIMENTAL METHOD

Indoor radon levels were measured with closed type dosimeters based on Makrofol ED etched track detector. The dosimeter consists of a hemispherical cup (internal radius r = 1.5 cm) of electrically conductive material as a diffusion chamber with a fibreglass filter, where all aerosol and radon daughters solid products are deposited. Therefore, only radon gas can diffuse through the filter. Makrofol foils are covered with aluminised Mylar. The dosimeters were exposed for 3 months in the period November 94 - February 95 and after collecting them, the detectors were etched electrochemically. The etching conditions for the Makrofol ED foils were obtained in a previous study which accounted for the diffusion chamber size (2). The optimal etching conditions found were: (a) chemical etching for 4 h, and (b) electrochemical etching (frequency: 3kHz, voltage: 1000 Vrms) for 1.5 h, at 40°C, using a mixture of 50% 6N KOH and 50% ethanol as etching solution. Tracks registered in exposed foils were counted in a 0.97 cm^2 surface area using a semiautomatic track density counting system set up in our laboratory (3). The sensitivity of the dosimeters was obtained by exposing several sets of dosimeters in the Radon Environmental Chamber at the National Radiological Protection Board (NRPB) Chilton Laboratory. The value of the sensitivity corresponding to the optimal etching conditions is (0.89±0.08) $tracks.cm^{-2}/kBqm^{-3}h$ (4). The reliability of the dosimeter calibration was checked in an European Intercomparison Exercise (5) . Background track density of Makrofol ED plates is 7 ± 2 cm^{-2} . The Radon Minimum Detectable Concentration (MDC) was calculated using the Currie (6) relations for well known background (7) and its value is 4 Bqm^{-3} for a 3 month exposure.

DISTRIBUTION OF DOSIMETERS

In the village of Teià, there are two types of houses: those situated in the village centre and those placed in the residential area, where the school is built. Multiapartment dwellings almost do not exist. The school staff placed 10 dosimeters in the school building, distributed in ten classrooms, five from the ground floor and five from the first floor. In addition, 15 pupils were selected to collaborate in the study by placing two dosimeters in their homes: one in the living area and the other one in their bedroom. A questionnaire was handed out together with the dosimeters in order to collect various physical features of the dwelling and of the life style of the occupants. As a result of the small size of the study, there were no dosimeters lost and only 2 questionnaires were missing.

The distribution of the dosimeters is shown in table 1.

Table 1. Distribution of the dosimeters

	Houses	Dosimeters			
		Total	Living area	Bedroom	Other
Residential area	7	14	6[(1)]	6[(1)]	
Village	8	16	7[(1)]	7[(1)]	
School		10			10 (classrooms)

[(1)] We do not know the placement of 4 dosimeters due to the two questionnaires lost.

RESULTS

Table 2 shows the results obtained in the residential area, in the village and in the school. These results indicate that radon levels in the school are similar to those corresponding to the houses where pupils inhabit and thus, the fact of going to school does not affect the radon levels at which pupils are exposed to. Even though the number of data is small, the indoor radon levels obtained are similar to those measured in a previous winter survey carried out in the Barcelona area (50 Bqm^{-3}) (4), and also to the world arithmetic mean value (40 Bqm^{-3}) given in the UNSCEAR 1993 report (1).

Table 2 Results of indoor radon measurements in the period November 94 - February 95

	Range	AM	GM	GSD	n
Residential area	19 - 94	46	41	1.68	14
Village	8 - 126	52	37	2.53	16
School	20 - 95	48	43	1.66	10

Radon concentration values are given in Bqm^{-3}

AM: arithmetic mean; GM: geometric mean; GSD: geometric standard deviation; n: number of dosimeters

In addition to the dosimeters distributed in living areas and bedrooms, one dosimeter was placed in the basement of a village house. The radon concentration obtained there was 198 Bqm^{-3}, higher than all the other values found in living areas and bedrooms. This result can be a consequence of the lack of ventilation of the basement and also of the fact that the room is in direct contact with the granite soil, typical of this region. Moreover, the radon concentration values obtained in the ground floor of the school building are higher than those obtained in the first floor (arithmetic means 61 and 46 Bqm^{-3}, respectively) confirming the soil as the most important radon source.

The results obtained constitute an upper limit to the indoor radon concentration annual average because radon measurements were performed in winter season when windows are kept mostly closed. Previous studies carried out in Barcelona confirm that winter concentrations are higher than summer concentrations (4). Thus, the estimation of the radiation dose from our results leads to an upper value for the annual dose that pupils receive. The effective dose was estimated for each pupil using the conversion factor given in the last UNSCEAR report (1) (3.6 nSv per $Bqm^{-3}h$ of radon exposure) considering an indoor occupational factor of 0.8 and assuming that pupils spend 5 hours at school, 10 in the bedroom and 4.2 in the living area. The mean value obtained was 1.2 mSv and the range 0.5 - 2.2 mSv. These values constitute an upper limit of the annual effective dose and are similar to the mean world values (1).

CONCLUSIONS

The indoor radon concentration values obtained in the public school of Teià and in 15 houses where pupils inhabit are similar and comparable to the mean world values.

An upper value of annual effective dose was estimated for each pupil taking into account the school, bedroom and living area radon levels and occupational pattern. The arithmetic mean was 1.2 mSv and the range 0.5 - 2.2 mSv.

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