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HIGH BACKGROUND RADIATION AREAS: THE CASE OF VILLAR DE LA YEGUA VILLAGE (SPAIN)

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The starting point of the Spanish experience in the study of High Background Radiation Areas is the development of a nationwide indoor radon survey carried out in 1988. This campaign, belonging to the first Spanish Radon Framework, consisted of approximately 2000 indoor radon measurements which represented a valuable basis to face rigorously the radon issue in Spain. Together but indepently from this survey, since 1991 the Spanish Nuclear Safety Council, the National Uranium Company and several Universities have developed the so-called MARNA project with the aim of estimating potential radon emission from external gamma dose rates, radium concentrations in soil and geological parameters.

During the last decade, several regional surveys have also been conducted to determine exposure to natural sources of radiation in different highly populated background radiation areas. Among them, the surroundings of the village of Villar de la Yegua Town, located in the western province of Salamanca, is the most important area of Spain from a radiological point of view, with the highest indoor radon concentrations, of up to 15,000 Bq m^{-3} being found there. Until now, the main result of the study in this area showed a geometric mean radon concentration of 818 Bq m^{-3}, which is 18 times higher than the national average. In this article, the results of the last survey, carried out in Villar de la Yegua during 2004 are summarised. A geometric mean radon concentration of 1356 Bq m^{-3} was found. Dose estimation coming from radon inhalation is also shown.

INTRODUCTION

During 1988, in the beginning of the Spanish Radon Programme, the research group belonging to the Department of Applied and Medical Physics of the University of Cantabria (Santander, Spain) carried out a national radon survey in Spanish houses(1). The data from 2000 measurements performed in this survey represented not only the first rigorous attempt to face the radon issue in Spain, but also a valuable tool to identify the High Background Radiation Areas (HBRA) in this country.

From 1991 a nationwide study called MARNA project(2) started with the aim of estimating potential radon emission from external gamma dose rates and radium concentrations in soil. Gamma radiation maps of the country obtained from this study are quite useful for designing new studies in specific areas or just as a reference to compare datasets obtained from different sources.

From the two above programmes, the village of Villar de la Yegua and its surroundings arose as the most important HBRA in Spain, where the highest indoor radon concentrations, up to 15,000 Bq m^{-3}, were found, and a mean effective dose from all natural sources of radiation as high as 267 mSv per year were estimated. The Villar de la Yegua area was first identified as HBRA after the study was carried out from 1988 to 1990 in which 55 Spanish populated areas were surveyed with regard to natural radiation exposure. From 29 dwellings studied in Villar de la Yegua, it was found that the 76% of houses showed radon concentrations higher than 400 Bq m^{-3} (EU recommended action level concerning radon concentrations in old houses)(3). The arithmetic mean concentration found was 1789 Bq m^{-3} leading to doses of 32 mSv per year. After this study, only few additional measurements were carried out in that area from 1995 to 1996 confirming the previous results and also showing other near villages with high indoor radon concentrations.

During 2004, in addition to the measurements performed within a national project in some workplaces located at Villar de la Yegua, a set of indoor radon measurements was carried out in a total of 56 houses. This paper summarises the results of this last survey, and the assessment of doses received by population due to radon inhalation.

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MATERIAL AND METHODS

A total of 61 measurements were made in the village using track etched detectors CR 39 exposed for a three-month period in order to evaluate average indoor radon concentrations. Detectors were generally exposed in single-storey houses and usually placed in livingrooms but sometimes in bedrooms. As the measurements were performed from May to August, in all the measurements, a seasonal correction factor of 1.45 was assumed in order to make the results obtained over a three-month exposure period representative of the actual mean annual indoor radon concentration(4).

For indoor radon measurements, the selected houses were those in which people spent all year long. The houses only occupied in summertime were not taken into account in this study. Some detectors were also exposed in public buildings as medical consulting, social centre, parochial centre, townhall, and tabern.

Mean annual effective doses from radon inhalation have been estimated by using ICRP65 dose assessment methodology[5]. The conversion factors used for radon exposure are 4 mSv per WLM and 5 mSv per WLM at home and at work places respectively, assuming an equilibrium factor of 0.4 for both situations and indoor occupancy 7000 h per year at home and 2000 h at work.

RESULTS

Table 1 shows the mean annual radon concentrations found in the public buildings analysed in Villar de la Yegua. As could be seen, the highest value obtained was in the medical consulting room with an annual average concentration of 5583 Bq m^{-3}, which would lead to an annual effective dose of 35.5 mSv for workers.

In Table 2 average radon concentrations at homes, each characterised by an identification code, are shown. The arithmetic mean radon concentration in the 56 houses measured was 1851 Bq m^{-3} and the geometric mean 1356 Bq m^{-3}, with arithmetic and geometric standard deviations of 1453 Bq m^{-3} and 2 Bq m^{-3} respectively. The above mentioned geometric mean is about 30 times higher than the national value of 46 Bq m^{-3}. Radon concentrations were higher than 400 Bq m^{-3} in 89% of the dwellings and higher than 1000 Bq m^{-3} in 71% of them. Bearing these measurements in mind, the mean annual effective dose from indoor radon exposure in the village of Villar de la Yegua is estimated to be 33 mSv, with a maximum dose value of about 110 mSv.

DISCUSSION

It must be noted that the presence of radon inside the buildings in the village is due to the radium content in soils of this area with concentrations ranging from 100 to 1000 Bq kg^{-1}[6]. Then, the results presented above can be used to improve the currently available data considerably with respect to the village of Villar de la Yegua in order to decide the countermeasures that should be taken for radon remediation in the dwellings.

Also it's necessary to remark that the workplaces measured are located in the former village's school, which surely means that children were exposed to very high radon levels in the past. This fact increases the justification of carrying out epidemiological studies on the health effects of radon exposure to the population living in this area, even though in mind its small population, of approximately 500 people. A previous epidemiological study[7] showed an increased risk of death due to lung cancer in the population living in the surroundings of the uranium cycle facility located nearby Villar de la Yegua village.

Taking into account the population-weighted average lifetime risk of lung cancer from radon exposure of 1.6×10^{-4} per Bq m^{-3} from BEIR VI[8] a lifetime risk of lung cancer of almost 30% for Villar de la Yegua village is estimated. This risk estimation is 35 times higher than that for the whole Spanish population[9].

Table 1. Indoor radon concentration in workplaces.

Public building	Radon concentration (Bq m^{-3})
Medical consulting room	55830
Social centre	4921
Parochial room	4253
Townhall	429
Tabern	179

Table 2. Indoor radon concentration in homes.

Home code	Radon concentration (Bq m^{-3})	Home code	Radon concentration (Bq m^{-3})
D35746	2486	D35791	303
D35747	847	D35793	583
D35750	233	D35794	2190
D35751	1901	D35795	831
D35752	4038	D35797	997
D35753	6209	D35799	1712
D35755	1182	D35825	5286
D35757	1188	D35826	530
D35759	634	D35827	730
D35760	4230	D35828	2068
D35761	2733	D35829	1690
D35764	1874	D35830	1300
D35765	2084	D35832	146
D35767	1523	D35834	1219
D35769	272	D35835	2066
D35772	1483	D35837	1769
D35773	625	D35838	1436
D35774	1805	D35839	1320
D35775	4337	D35840	3370
D35776	1283	D35841	1374
D35778	1140	D35842	979
D35781	402	D35843	1586
D35782	4272	D35844	1994
D35783	386	D35846	2202
D35785	1037	D35847	256
D35786	5621	D35848	1075
D35787	1117	D35851	4993
D35788	2956	D35853	1747

Table 3. Summary of indoor radon concentration for houses and workplaces (AM: arithmetic mean, GM: geometric mean, SD: standard deviation).

	AM (Bq m^{-3})	ASD (Bq m^{-3})	GM (Bq m^{-3})	GSD (Bq m^{-3})	Range (Bq m^{-3})
Houses	1851	1453	1356	2	146–6209
Workplaces	3073	2573	1551	5	179–5583

Finally, the comparison between the MARNA project's predicted map of potential indoor radon concentration and those obtained from the present study shows a good correlation (Table 3)[10]. This agreement has been found on a national basis (scale 1:1000000) showing the importance of maps as those from MARNA Project.

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