Continuous radon monitoring in workplaces: radiological implications

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Abstract

The new EURATOM basic standards for radiological protection recently incorporated to the Spanish law (BOE 178/2001) contain, in the Title VII, which deals with exposure by natural radiation sources, a request at the EC Member States to determine the working places which are of importance with regard to this exposure.

High concentrations of radon exist in non-uranium mines and caves, in various underground excavation works and other underground workplaces. In this sense, in its 1990 publication, the ICRP recommended that high exposures of radon in workplace could be regarded as the responsibility of the operating management and should be considered as occupational exposure.

The estimation of real doses received by workers is essential to identify the above places and to decide about the regulation of exposure of the people working there. Integrated passive measure systems (e.g track etched detectors) give only information about average radon concentrations. However in many situations, this value do not provide enough information about the real exposure of workers because the knowledge on the evolution of radon concentration is needed.

In the framework of a national survey in workplaces, this paper shows a dose estimation comparison concerning radon issue in two different situations on which radon measurements have been carried out by two separate methods; integrated (by using CR39 detectors) and continuous (by using SARAD DOSEman).

Keywords: radon monitoring , workplace, dose assessment

Introduction

Since 2001, Spanish law incorporated EURATOM basic standards for radiological protection (1), which include a request at the EC Member States to determine the working places on which exposure to natural radiation is significant. On Title VII (BOE 178/2001) radiation coming from natural sources has analogous role than radiation emitted from artificial ones used to.

It is well known that radon is responsible of about 50 % of the total dose received by population due to natural sources of radiation (2). Radon concentrations can be usually high in poorly ventilated enclosures build upon elevated radium content soils. In many of them, such as caves and other underground places, people carry out work activities and their exposure should be, from a radiological point of view, considered as occupational. The identification of these places can be achieved measuring radon concentration by means of integrated passive measure methods, like track etched detectors which provide the radon average concentrations for several months period. However, in order to regulate worker's exposure to high radon levels it is essential to know also the possible periodic variations in time of the actual concentration as a criteria for planifying the minimum total exposure time as well as the adequate the working shifts that minimize the total dose received by the worker. For doing so, continuous radon monitoring over shorter periods of time (in the order of days) are needed as a complementary value of integrated average concentration.

In this communication, two examples of workplaces on which integrated radon concentration is not enough to determine the real exposure of workers are presented. In these places, the dose estimated from average concentration significantly differ from that obtained by considering the real mean concentrations in the different working shifts.

Material and methods

The first studied workplace was a tunnel where mineral is transported throughout a conveyor belt in the mine of Saelices el Chico in Salamanca (SPAIN). The main tasks for the workers are those related with general maintenance of the engines and electric control. The second workplace is a medical consulting room build upon the high background radiation area of Villar de la Yegua, also located in the region of Salamanca (Spain).

Integrated measurements were made throughout the above mentioned places using CR-39 track-etched detectors, exposed for a 6 months period in order to evaluate average indoor radon concentrations. On the other hand, continuous radon monitoring was performed during 9 days in the tunnel and 10 days in the medical consulting room, by using the DOSEman radon dosimeter from SARAD GmbH. This system use semiconductor detector technology and is based upon the use of alpha spectrometry of the radon progeny (^{218}Po and ^{214}Po) present inside the detector chamber, and cover a measurement range of radon concentrations from 10 to 4 10^{6} Bq m^{-3}. Radon concentration can be recorded each hour in a non volatile memory.

Mean annual effective doses coming from radon inhalation have been estimated by using ICRP65 dose assessment methodology (3). The conversion factors used for radon exposure are 5 mSv per WLM at work, assuming an equilibrium factor of 0.4 and indoor occupancy 2000 hours per year.

Results and discussion

Average radon concentrations obtained by integrated passive method was of 3570 Bq m^{-3} in the tunnel and 3900 Bq m^{-3} in the medical consulting room, which represent an average effective dose rates of 22.71 and 24.8 mSv y^{-1} , respectively.

The results of continuous measurements were analysed by dividing the whole measurement period into three time intervals which correspond to the working shifts in the respective workplaces (S1: from 6:00 to 14:00, S2: from 14:00 to 22:00 and S3: from 22:00 to 6:00).

Figure 1 shows the results obtained in the tunnel, where maximum mean radon concentrations as high as 14500 Bq m^{-3} were estimated in the S2 shift, which would lead to an effective dose rate of 92.34 mSv y^{-1}. Mean radon concentrations measured during 9 days were of 1988 Bq m^{-3} on S1 shift, 7554 Bq m^{-3} on S2 shift and 1693 Bq m^{-3} on S3 shift, corresponding with mean effective dose rates of 12.64, 48.04 and 10.76 mSv y^{-1} respectively. So, it can be seen that the average dose rate estimated from integrated measurement, 22.71 mSv y^{-1}, overestimates those calculated for S1 and S3 shifts in about 80 % and 210 % respectively. On the other hand, the same value underestimates the actual dose received by people working in the S2 shift in about 90 %.

The above-mentioned differences were lower but also significant in the case of the medical consulting room. Figure 2 shows the evolution in time of radon concentration in this place, where maximum mean radon concentration of 6760 Bq m^{-3} was estimated during the S1 shift. This value would represent a mean effective dose rate of 43 mSv y^{-1}. Mean radon concentrations calculated along 10 days were of 3650 Bq m^{-3} on S1 shift, 3100 Bq m^{-3} on S2 shift and 3940 Bq m^{-3} on S3 shift, corresponding with mean effective doses of 23.21, 19.72 and 25.06 mSv y^{-1} respectively. Thus, the average dose rate obtained from integrated radon concentration, 24.8 mSv y^{-1}, significantly overestimates the one obtained during S2 shift in about 26 %. However, the value is not significantly different from those estimated for S1 and S3 shifts.

In conclusion, when high radon concentrations are detected in a working enclosure, remedial actions must be taken in order to reduce indoor gas concentration as low as possible. After that, general criteria on radiological protection demand to get the worker’s exposure as low as reasonably achievable, the well known ALARA criteria (ICRP). The practical application of this criteria need to take into account factors like total exposure time and working time distribution. The two examples showed in this paper illustrates some information needed for making good decisions about protecting workers in a high radon environment.

References

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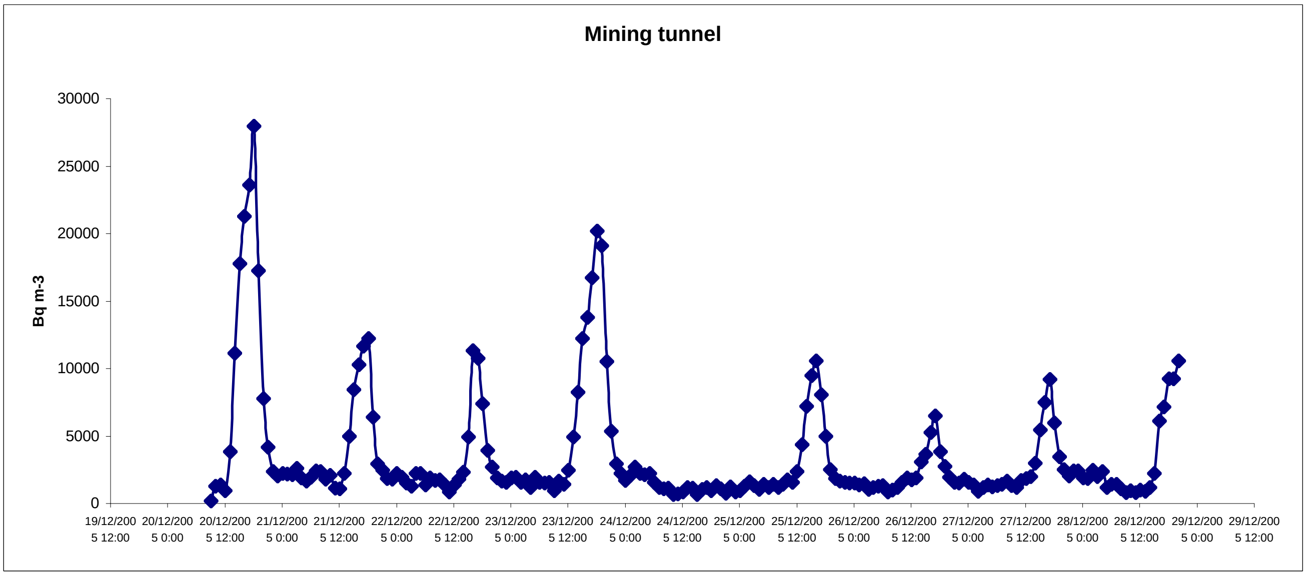

Figure 1: Time evolution of radon concentration inside the tunnel

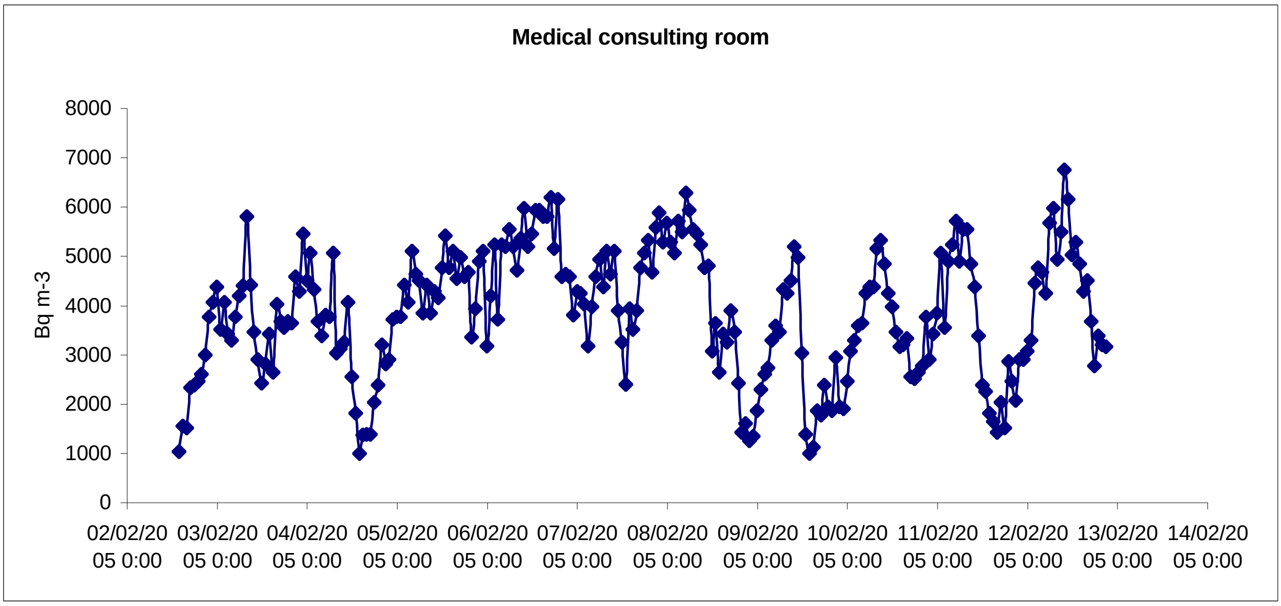

Figure 2: Time evolution of radon concentration in the medical consulting room