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Real-time indoor radon exposure in the city of Zacatecas, Mexico

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RESUMEN

El ^{222}Rn y sus descendientes son considerados un riesgo para la salud; por esta razón, se midió continuamente la razón de exposición al ^{222}Rn y sus descendientes para obtener niveles ambientales de referencia en Zacatecas. El monitoreo se realizó desde junio de 2000 hasta junio de 2001. El fondo se midió con los sistemas RM-70 y RM-60 basados en detectores Geiger Mueller. El sistema RM-70 fue acoplado a un conjunto filtro ventilador de aire y fue usado para medir continuamente la concentración de partículas alfa provenientes del decaimiento del radón y sus descendientes presentes en el aire. Las razones de exposición encontradas están dentro del rango de 21μR/hr a 30μR/hr. Se comparan las razones de exposición para distintos periodos de tiempo.

PALABRAS CLAVE: El radón 222, espacios cerrados, dosimetría, exposición.

ABSTRACT

^{222}Rn and its daughter elements are considered dangerous for health. Exposure was measured to find the radon reference levels in Zacatecas. Indoor levels were measured since June 2000 until June 2001. RM-60 and RM-70 Geiger Muller-based systems were used to measure radiation background. The RM-70 system was coupled to a fan-filter and used to detect alpha decay from radon and its daughters. The mean exposure rates were in the range from 21mR/hr to 30mR/hr. The exposure rates were compared for different periods of time.

KEYWORDS: radon-222, indoors, dosimetry, exposure.

INTRODUCTION

All living organisms are continuously exposed to natural environmental radioactivity, as well as to artificial radiation. The exposure varies as a result of human activities. The highest internal dose is due to ^{222}Rn and its decay products (UNSCEAR, 2000). Indoor air should be monitored to know the levels of radiation at which population are exposed, and implement appropiate countermeasures to protect the population and the environment. (Lin *et al.,* 1999).

^{222}Rn is a natural radioactive gas, generated from the decay of ^{226}Ra that exists in different amounts in all types of soils (Ayotte *et al.,* 1998). Prolonged exposure to high concentrations of ^{222}Rn and its decay products have been associated with increase of lung cancer risk for humans (Steck *et al.,* 1999; BEIR VI, 1999). This health risk can be reduced if the ^{222}Rn exposure is limited considering that it can't be avoided (Fujimoto, 1998). In order to assess the radiation exposure due to the inhalation of ^{222}Rn and its daughters in the city of Zacatecas, exposure levels determinations were performed in a room for long enough periods to estimate indoor radon in real time dependence.

EXPERIMENTAL WORK

Two kind of detectors were used to measure the real time exposure level of background and ^{222}Rn and its decay products: a RM-60 and a RM-70; both systems were interfaced to a PC. These detectors were calibrated with a ^{137}Cs standard (661.6 keV) (AWARE Electronics, 1998). The RM-60 system was used to measure Geiger type reference background and the RM-70 system was coupled to a fan filter and used to measure the ^{222}Rn and its daughters. The ^{222}Ra and its decay products alone or attached to air particles are catched in the 5 μm filter causing an increase in the detector's counting rate directly related to the concentration of those radioisotopes that were presented in the atmosphere.

The detector system counted continuously the particles who arrived and decayed at the filter; the system was set to count the particles arriving at the fan filter every 10 seconds. Then, the number of radioactive particles who arrived at this time were averaged by the software of the system. The system always counted by fixed periods until interruption in the power system ocurred and computer and detectors were restored. The counting lapses are shown in Table 1.

Table 1

Typical periods during one year

Counting period	Total counting time (days)	Season
June 2-12, 2000	9.88	spring
September 12-23, 2000	11.27	summer
October 28- December 20, 2000	53.31	autumn
February 16- March 14, 2001	25.97	winter
June 5-20 2001	14.98	spring

RESULTS AND DISCUSSION

The results obtained in spring, summer and autumn are shown in Figures 1 to 3. Figure 1 shows the exposure rate levels during a week in spring 2000. The average exposure rate for this week was 38 µR/hr. All the days showed a peak that occurred around 8:00 am. Figure 2 shows the results of 10 days exposure during September. This behaviour was similar to Figure 1.

Exposure rates and dayly averages for twenty-five days were measured in december 2000 they are shown in Figure 3. The exposure in a typical winter day is shown in Figure 4. There was a maximum concentration that was found as the room remained closed, the maximum exposure occurred at 08:10:00 am. The trend line shows the average for this typical day exposure.

The background and the typical average exposure rate for a month, a week and a day for each season is presented on Table 2. The higher values correspond to December, when the room remained closed most of the time. It's noticeable that dayly exposure rate averages are higher than weekly's, but this is only a variation due to the number and value of each considered point to obtain the average.

An important remark is that there is a periodicity in the behavior of the levels for every day. This is the characateristic behavior for radon concentration in real time, so the system measured on exposure rate. This behavior is in accordance with publised results. A comparisson with the results of (Vaupoti_ *et al.,* 2001) showed they are simi-

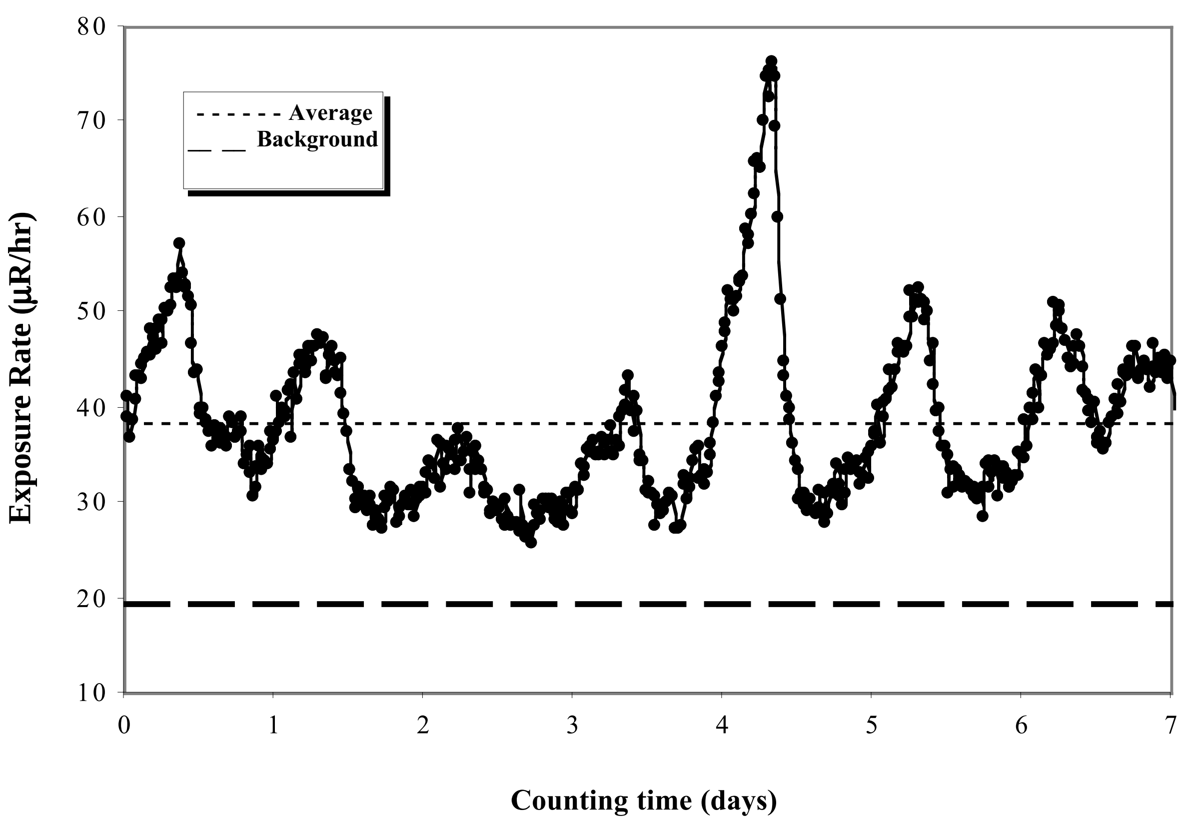

Fig. 1. Exposure rate in a typical spring week (June 2000).

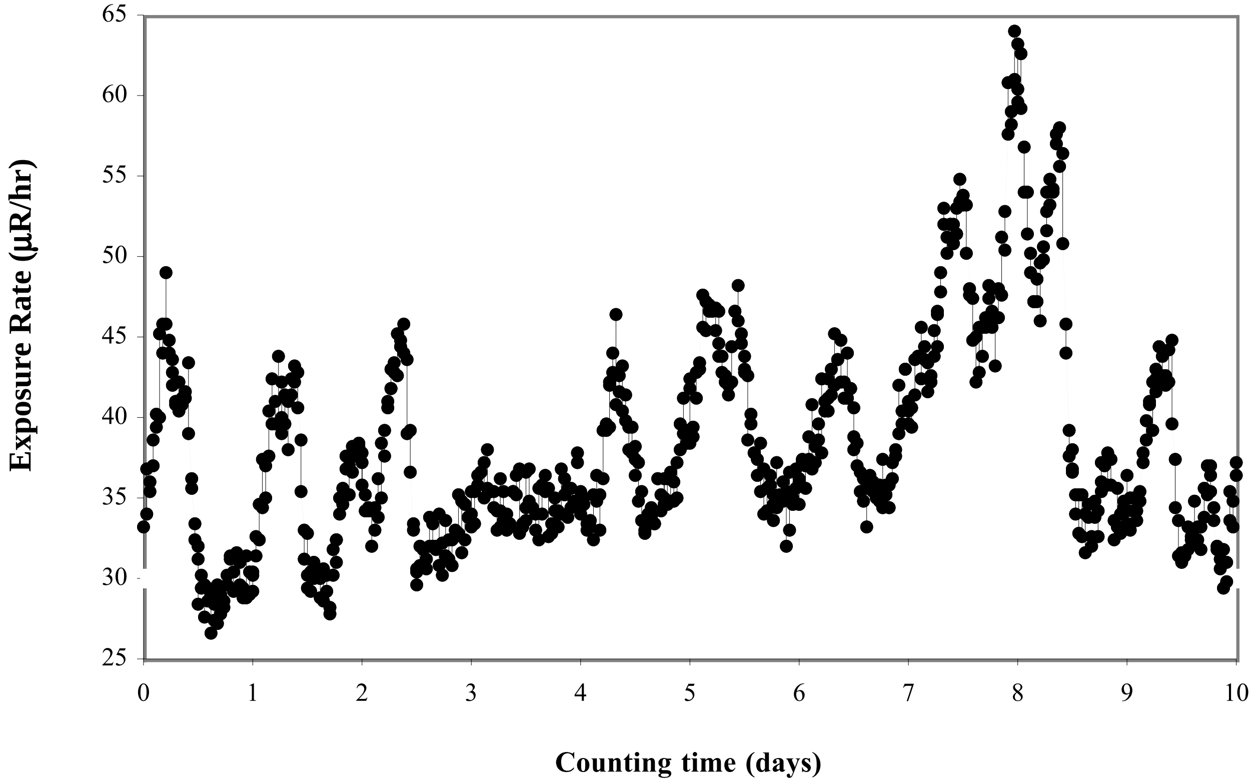

Fig. 2. Exposure rates during 10 days in summer 2000.

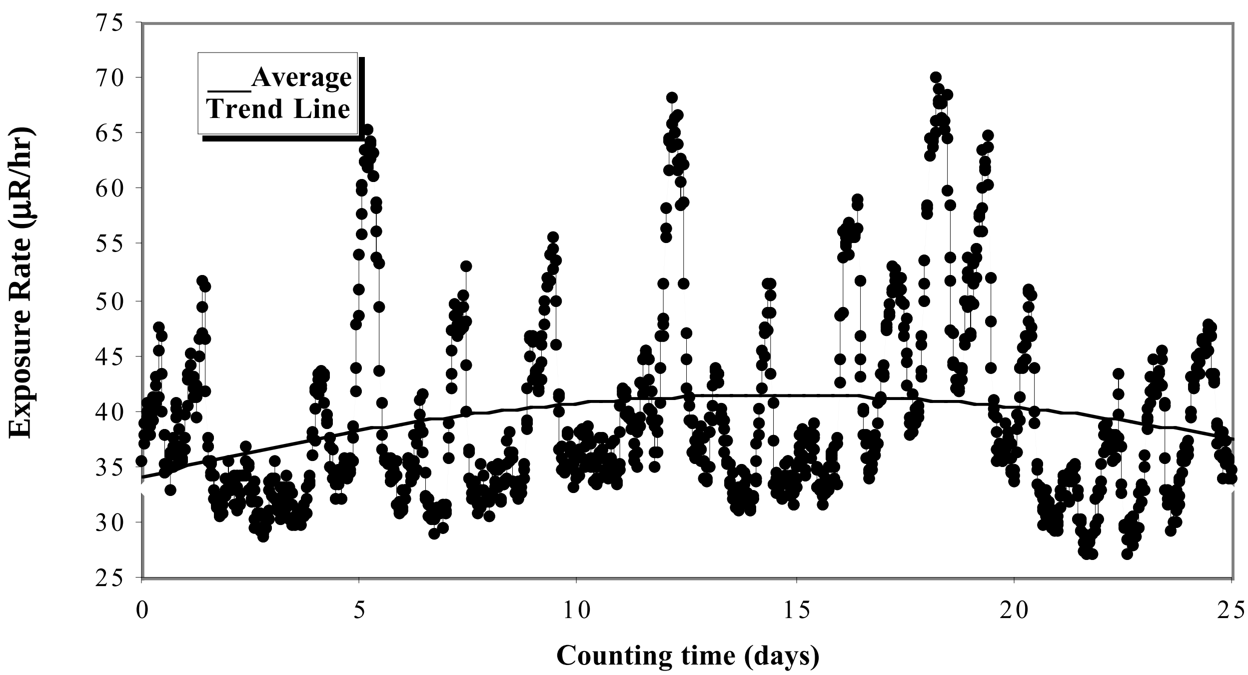

Fig. 3. Average exposure rates for 25 days in autumn 2000.

Table 2

Average exposure rates for a month, week and a day during different seasons, using RM-60 and RM-70 systems

Device	RM-60 system	RM-70 System		
Month	**Background (μ R/hr)**	**Average exposure rate (μ R/hr)**		
		month	**week**	**day**
June 2000	18.0±0.1	35.74±0.02	38.4±0.4	44.5±0.2
September 2000	18.30±0.05	38.56±0.05	38±2	48.0±0.3
December 2000	19.14±0.05	39.7±0.5	43.5±0.5	53.5±0.2
March 2001	18.55±0.02	33.34±0.05	33.4±0.4	36.0±0.1
June 2001	18.02±0.01	31.0±0.1	34±1	36.3±0.3

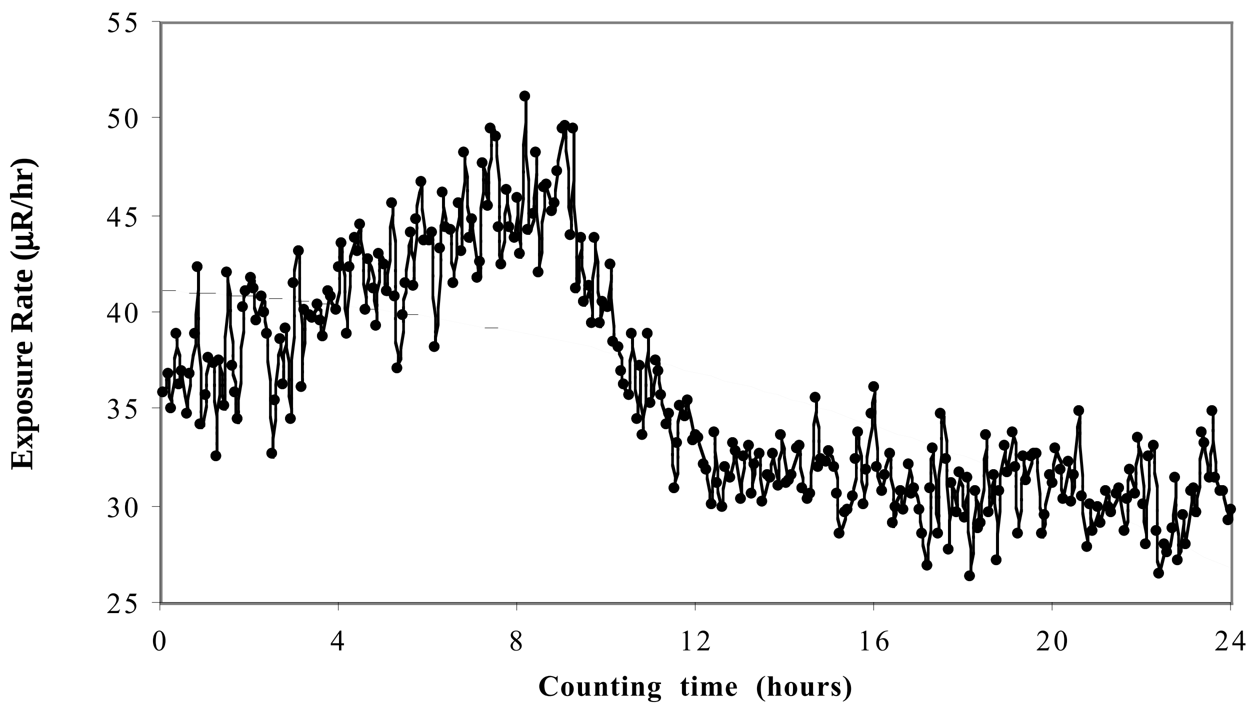

Fig. 4. The exposure in a typical winter day in February 25, 2001.

lar, because there is an increase in concentration for winter season. (Merrill and Akbar-Khanzadeh, 1998) showed in their results variations in concentration levels for every month, where the highest values occurred on December; and the profile for radon concentration levels for a day is similar to the Figure 4, where the maximum exposure occurs between 7:00 and 9:00 am.

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