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Real time radon variation indoors

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RESUMEN

En un laboratorio controlado, localizado a 36 km de la ciudad de México a una altitud de 3000 m, donde se encuentran cámaras experimentales de radón, se realizaron medidas en aire de ^{222}Rn en tiempo real. Durante un período de dos años se midió la concentración de radón, la temperatura y la humedad relativa en el aire del laboratorio con un equipo ALPHAGUARD colocado a 2 m de altura con respecto al piso. El tiempo de integración para obtener la información fue programado cada hora. Los resultados obtenidos mostraron que existe en promedio una concentración de actividad debida al radón de 40 Bq/m^3. Las fluctuaciones de radón se correlacionaron con las variaciones de temperatura en el interior del edificio. Se encontró que existe una anticorrelación entre el radón y la humedad relativa para períodos largos de medición. La presencia de la cámara de radón no influyó en las variaciones de radón en el laboratorio.

PALABRAS CLAVE: Radón ambiental, medidas en tiempo real, laboratorio controlado, correlación de temperatura y humedad.

ABSTRACT

Real-time indoor radon measurements have been performed in a controlled laboratory located 36 km from Mexico City at 3000 m altitude where experimental radon chambers exist. Radon was evaluated with an ALPHAGUARD equipment above installed at 2 m height from the floor, during a period of two years. Temperature and relative humidity were also recorded. The measuring time was programmed to integrate information every hour. The results showed average radon levels of 40 Bq m^{-3}. Radon fluctuations were correlated mainly with local temperature variations in the building. An anticorrelation of radon with humidity was found in the long term. Radon variations indoors were not influenced by the presence of radon chambers in the laboratory.

KEYWORDS: Indoor radon, automatic real time data, controlled laboratory, humidity and temperature correlation.

INTRODUCTION

The main source of indoor air radioactivity is ^{222}Rn and its decay products. ^{222}Rn is produced from the decay of ^{226}Ra present in the soil and building materials and penetrates in dwellings through fissures. It has been reported that radon and its decay products have higher concentration values in closed environments (Huet *et al.,* 2001; Kennedy and Gray, 2001). People working in radioactivity laboratories that manipulate uranium must be subject to exposure control of radon, in order to avoid internal exposure by inhalation. Evaluation of radon reduction and prevention programmes have to be implemented since leakage failures or poor ventilation can increase the radon and daughters concentration in working places (Merrill and Farhang, 1998).

During a two year period, a survey of real time radon was performed in the indoor atmosphere of a controlled laboratory having radon chambers that are usually used for detectors exposure. The laboratory belongs to the Nuclear Centre of Mexico, 36.5 km from Mexico City at an altitude of 3000 m. Occupationally exposed personnel works within the laboratory and the control of the radon chambers is performed following safety procedures.

The aim of the present paper is to analyse the radon fluctuations observed in the laboratory atmosphere in order to assess the radon exposure to the workers that can be caused by a leakage failure of the radon chambers.

Experimental

The laboratory has a total volume of 200 m^3 and its approximate height is 5.5 m. The access is controlled by a normally closed door. At the upper part, four windows exist which directly communicate to the outside. These windows have a 10 cm separation from the building structure, permitting a natural ventilation of the room that continuously exchanges the indoor air without violent air flows. No air conditioning exists in the building and temperature and humidity are a function of environmental changes at the site. It is worth mentioning that the rainy season occurs from May to October and the yearly average temperature at the site is 11°C.

Radon, temperature and relative humidity were measured with an ALPHAGUARD (Genitron Instruments GmbH). The equipment has an ionisation chamber of 0.62 litres, where environmental radon diffuses through a glass fiber membrane having a 99.9% retention factor for radon daughters. The equipment was fixed for radon monitoring at

the laboratory at 2 m above the floor during a period of 20 months, except when used in other tasks.

The instrument was programmed to record radon, temperature and relative humidity each hour, 24 times a day. The stored results were daily, weekly and monthly averaged.

RESULTS AND DISCUSSION

The data obtained in the hourly records of radon, temperature and relative humidity are shown in Figure 1. In this case radon, temperature and relative humidity had similar patterns except when temperature gradient changes sign. In this case the increasing temperature generates the abrupt radon and humidity lowering. The radon increase during the early morning at the site (from 00:00 till 08:00) has already been reported indicating an enhanced exhalation during the night period in correlation with a lowering temperature (Segovia *et al.,* 2001). It is noticeable that radon has a sudden decrease from 08:00 to 09:00, when workers arrive to the laboratory and the door is opened. The radon levels are quite low, not higher than 70 Bq m^{-3}, showing only the daily fluctuations, not influenced by radon chambers manipulation during the day. The lower radon data are between 09:00 and 18:00, when the workers are in the laboratory. The opening of the door is probably related to the radon lowering.

The daily behaviour during a whole week of radon, temperature and relative humidity is shown in Figure 2. In this figure, the evidence of working days and weekend days having the same pattern indicate also that the radon fluctuation are related mainly to the temperature variations in the laboratory. The humidity has less correlation with the radon fluctuations than temperature. The maximum radon levels are low and quite stable in their values reaching no more than 80 Bq m^{-3} each day during the early morning. No noticeable radon increase with the radon chambers manipulation during the labour days was observed.

The seasonal effect of radon, temperature and relative humidity is indicated in Figure 3 where the monthly averaged data are displayed from July 1999 to March 2001. In the long term a clear correlation occurs between temperature and radon and an anticorrelation between radon and the relative humidity, particularly during the months when heavy rains occur in August-September. During the

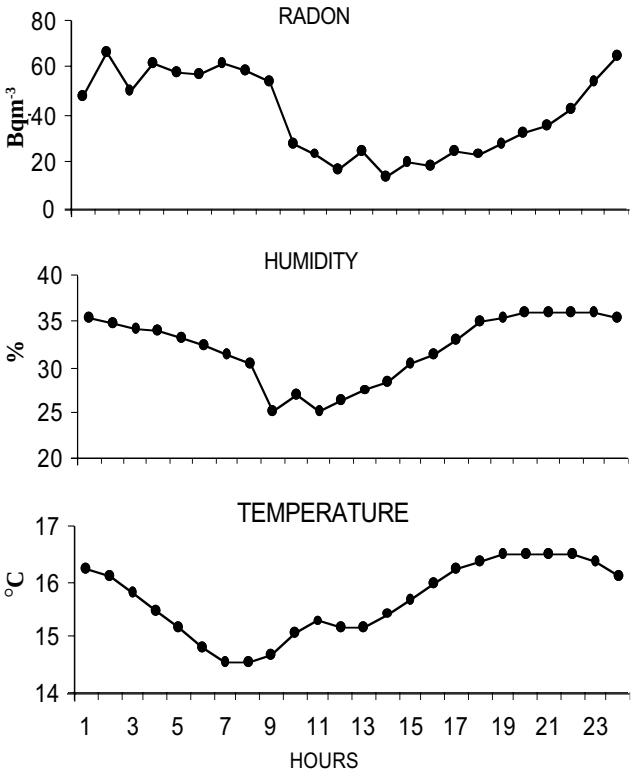

Fig. 1. Hourly radon, temperature and humidity data in a 24 hours period.

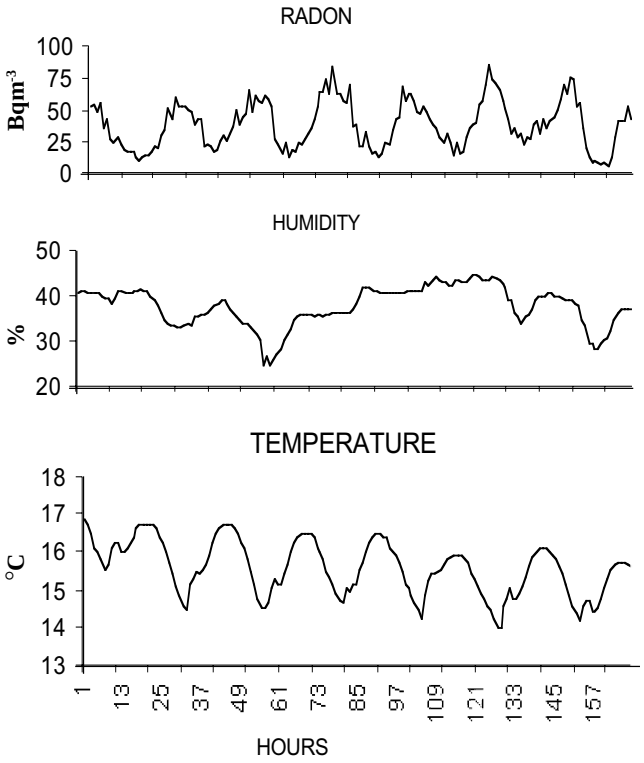

Fig. 2. Daily averaged radon, temperature and humidity data during a week.

dry season (December-March) a better correlation is observed between radon and relative humidity. When all 20 months data were analysed the radon, humidity and temperature data had a correlation coefficient lower than 0.3. However, when data from the dry and rainy season were separated a 0.9 correlation factor was obtained between temperature and radon when humidity was lower than 30%. The monthly averaged data had very low radon values, with a yearly average concentration value of 40 Bq m^{-3}. These data are lower than values obtained indoors in family dwellings of the zone (Franco-Marina *et al.,* 2001) where daily fluctuations can reach 350 Bq m^{-3}. Those household dwellings, close to the site, have very similar soil characteristics. However the essential difference belongs to the fact that the laboratory is built at the second floor, having a ground level below, while the household dwellings of the zone have the living room at the soil level with no underground construction.

CONCLUSIONS

No remarkable increase of radon has been observed, other than the seasonal, temperature and humidity dependent, during the monitoring time related to the radon chambers presence at the laboratory. The chambers are used for detectors exposures but no effect is observed in the laboratory atmosphere, indicating that no leakage failures or mismanagement in the chambers manipulations generating radon exhausts occurs.

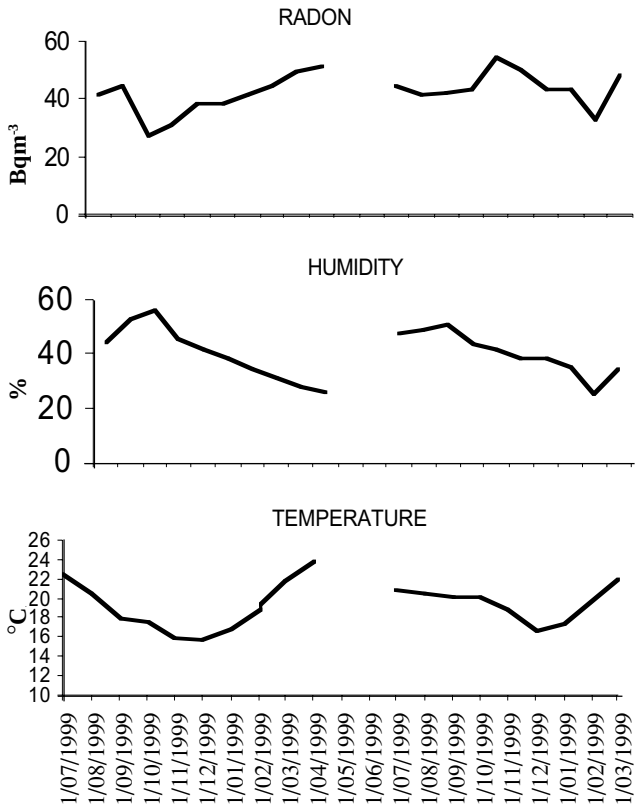

Fig. 3. Monthly averaged radon, temperature and humidity for a 20 months period.

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BIBLIOGRAPHY

FRANCO MARINA, F., N. SEGOVIA, W. RUIZ, L. GODÍNEZ, L. TAVERA, A. LÓPEZ, A. CHÁVEZ, P. PEÑA and G. PONCIANO, 2001. Short and long term indoor radon survey in Mexico City. *Radiat. Meas. 34*, 545-548.

HUET, C., G. TYMEN and D. BOULARD, 2001. Size distribution, equilibrium ratio and unattached fraction of radon decay products under typical indoor domestic conditions. *Sci. Total Environ. 272,* 97-103.

KENNEDY, C. A. and A. M. GRAY, 2001. Health economics analysis of radon remediation programmes. *Sci. Total Environ. 272,* 9-15.

MERRILL, A. E and A. K. FARHANG, 1998. Diurnal and seasonal variations of radon levels, effects of climatic conditions, and radon exposure assessment in a former Uranium metal production facility. *Health Phys. 74,* 568-573.

SEGOVIA, N., G. PONCIANO, F. CENTENO and A. CHÁVEZ, 2001. Air radon: A support for epidemiological studies. Proc.5th Int. Conf. on Rare Gas Geochem., Eds. Hunyadi I., Czije I. and Hakl J. Debrecen, Hungary. 181-188.

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