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A study of daily and seasonal variations of radon concentrations in underground buildings

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Abstract

A study of daily and seasonal variations of radon concentrations in underground buildings in major cities of China was carried out. According to the data from the Model 1027 continuous monitor, radon concentrations in the underground buildings changed through two cycles each day. The first cycle was from 12:00 to 0:00 and the highest or lowest value, depending on location, was at about 19:00. The second cycle had a little change. Based on the data from solid state nuclear detectors (SSNTDs), it was concluded that the radon concentrations in underground buildings in winter were lower than in summer, which was opposite to that above the ground level. Similar to that above the ground level, the radon concentrations in spring were close to the year-round average radon concentrations.

Keywords: Daily; Seasonal; Variation; Underground buildings; Radon concentration

1. Introduction

Radon (^{222}Rn) is a radioactive gas arising from the uranium decay chain, and is the largest single source of radiation exposure to many populations (Fovt et al., 1999). Inhalation of radon and its daughter products can cause a significant health hazard when they are present in

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enhanced levels (Singh et al., 2001). Radon has the highest level in basements and underground buildings that are in contact with the soil (Anastasiou et al., 2003). Exposure to radon has become a great concern to people working in underground spaces (Shui et al., 1999; Shouming and Puling, 2004).

It has been reported that above ground level, radon concentration is the highest in winter and the lowest in summer, whereas radon in autumn is similar to that in spring and these seasons are both close to the annual average radon concentration (Xiehua, 1996; Suozhao and Yihe, 1996; Kullab et al., 2001; Dwicedi et al., 2001). To reduce the radon concentrations in underground buildings with efficient measures, it is important to know the daily and seasonal changes. However, the seasonal radon variation in underground spaces has yet to be studied in detail in China.

Solid state nuclear detectors (SSNTDs) and continuous radon monitors were used to study daily and seasonal variations of radon concentrations in underground buildings in major cities of China. Among those, data are obtained for 87 underground buildings in spring, summer and winter, and for 191 underground buildings in summer and winter. In addition, data in some sites were obtained from Model 1027 continuous monitor to study radon daily variation.

2. Materials and methods

Measurements were carried out employing CR-39 detectors made in China. The CR-39 uses allyl diethylene glycol carbonate, which is sensitive to α particles and is used widely in accumulating radon measurements. The detectors were 1×1 cm and were mounted in a detector box with a filter film to remove radon daughters. The detector boxes were hung in underground buildings at a distance of about 20 cm from any surface. Radon diffused into the detector box and decayed to its progeny. The alphas originating from radon and its progeny were registered as tracks in the detectors. The detectors were exposed in underground buildings for about three months before they were retrieved from all sites and were etched in 7 N KOH at 70 °C for 6 h.

The detector was calibrated by the Radon Laboratory, School of Nuclear Science and Technology, Nanhua University in Hengyang, China, which is the Asian regional coordination laboratory for the International Radon Metrology Program (IRMP). A density of 4.218 tracks cm^{-2}/(kBq m^{-3} h) was obtained for ^{222}Rn. Track densities were obtained from the detectors using optical microscopes at a magnification of 630×. A total of 500 counts were made or the surface area for counting was about 0.25 cm^2 per detector. To measure variation, 17 sites had duplicate measurements, and the variation coefficients were less than 20%. The detection limit was 8.654 Bq m^{-3} if the detectors were exposed for three months.

Detectors were also calibrated for ^{220}Rn in the same situation as for ^{222}Rn, and we obtained 0.159 tracks cm^{-2}/(kBq m^{-3} h), which accounted for 3.8% of that of ^{222}Rn. Hence the obtained data are mainly from ^{222}Rn.

Model 1027 continuous monitor from Sun Nuclear Corporation, U.S.A., was chosen to measure the radon concentrations at some sites for over 24 h to study daily variations. The monitor is a patented electronic detecting device using a diffused-junction photodiode sensor to measure the concentration of radon gas, and has been evaluated and accepted by the U.S. Environmental Protection Agency. The monitor was calibrated by the same laboratory in Nanhua University before use.

The underground buildings studied included basements, parking garages and tunnels. The basements and parking garages were under high buildings, and people are working in them. Some tunnels were built in war as air-raid shelters and now most of them are normally closed. Some were built in peace. There are 2 construction types of tunnels: one was built in mountains and are called saps in this paper, and the other was built in soils and are called tunnels in this paper.