Study on indoor air radon measurement in a university in Shanghai

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Abstract: With the improvement of people's requirements for living environment, the effect of indoor radon radioactivity on health has been widely concerned. In this paper, taking a university in Shanghai as an example, indoor radon concentration and its related environmental parameters were measured in some of its houses to understand the level of indoor radon concentration in its campus. The results show that the average concentrations of student dormitory, office building, and academic building are 14.79±9.15 Bq/m^3,22.67±5.72 Bq/m^{3,} and 12.55±6.71 Bq/m^3 respectively. indoor radon is positively correlated with indoor temperature and humidity, and ventilation is also an effective method to reduce indoor radon.

Keywords： Indoor radon; environment parameters; campus; measure

1. Introduction

Radon, as a widespread natural radiation source, and the radiation dose generated by the decay of radon gas alpha particles and their daughter bodies can cause radiation damage to the human respiratory system [1~3]. In daily life, the radiation dose generated by radon and its daughter decay accounts for about 50% of the total radiation dose generated by natural radiation sources [4]. Meanwhile, radon has become the second most carcinogenic factor after smoking.

Modern research shows that long-term exposure to indoor radon concentration will increase the risk of lung cancer. In addition, radon may trigger malformation, genetic malformation inheritance, leukemia, and other adverse consequences. Therefore, the effect of radon concentration in the indoor environment on human health has become a major problem that needs to be solved in the theoretical field [5]. Through the survey, it was found that the study of indoor radon on campus is still immature. To better understand the indoor radon concentration levels and factors affecting indoor radon in some buildings on campus, three typical buildings with relatively dense populations in colleges and universities were selected in this paper [6~7].

2. Material and methods

The sampling included student dormitories, office buildings, and academic buildings. A total of 59 rooms were tested, and it took 1.5 years. The indoor and outdoor radon concentrations, indoor and outdoor temperature and humidity, and carbon dioxide were tested by the method of room entry. Building characteristics in the measurements included room geometry, number of room floors, and air exchange rate calculated by CO_2[8~9]. In addition, occupant conditions and activity characteristics were recorded for an average of 1 hour. In the actual measurement, the suction mode was adopted, in which the outdoor air radon concentration was measured in the first and the last hour. The suction port is placed near the window and 1.2 meters above the ground; each measurement is made for 10-12 hours and the room is kept in normal use during the measurement period.

Radon gas measurement adopts RAD7 radon meter (SURRIDGE, USA) with a correction coefficient of 1, and the measurement period is 1h, the number of measurement periods is 8, and the measurement mode is AUTO. indoor and outdoor temperature and humidity adopt Jianke Renda C0S-03, and a set of data is measured every 5min. The CO2 exhaled by the human body was collected with

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 https://doi.org/10.1051/e3sconf/202235605040

Xinster HT-2000 and converted to respiration rate according to the number of people in the room per hour[10~12].

3. Results and discussion

3.1Indooor radon concentration

It can be seen from the figure that the log indoor radon concentration is normally distributed, and the maximum indoor radon value is 65.5 Bq/m³, the median is 12.93 Bq/m³, and the arithmetic mean and geometric mean are 14.68±12.41 Bq/m³.In this study, a total of 59 rooms were tested, including 47 student dormitories, 2 office buildings, and 10 academic buildings, and their average values were 14.79±9.15 Bq/m3, 22.67±5.72 Bq/m3, and 12.55±6.71 Bq/m3, respectively. The results showed that the tested values were all lower than the standard limit value of 150 Bq/m3, probably because of the outdoor soil radon concentration in Shanghai It may be because the outdoor soil radon concentration in Shanghai is lower and the indoor infiltration rate is lower, which leads to the generally low indoor radon concentration.

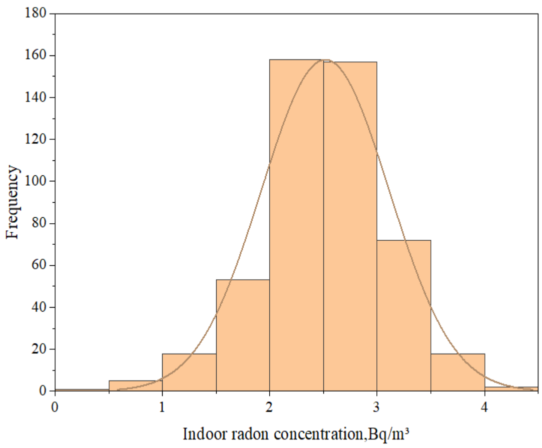

Fig.1 Indoor radon test in a university in Shanghai

3.2 Seasonal changes and indoor radon

In this paper, student dormitories, office buildings, and academic buildings with high daily utilization rates and high mobility of students in college campuses are selected as the research objects, and their indoor radon concentration is measured, and the results are shown in Figure 2.

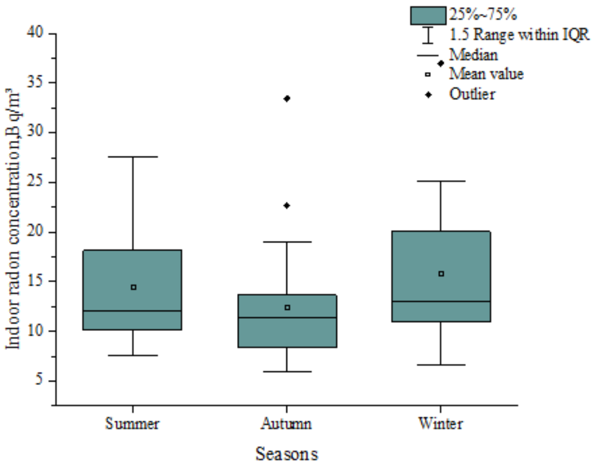

Fig.2 Indoor radon concentration in different seasons

It can be seen from Figure 2 that the indoor radon concentration in summer and winter is higher than that in the transitional season, probably because the air conditioner is closed in the transitional season and the windows are opened for a longer period, resulting in a lower radon concentration; in summer and winter, because the air conditioner is opened, radon and its daughters will accumulate a lot, making the radon concentration high.

3.3 Building type with indoor radon

The test sites include three typical buildings, namely, student dormitory, office building, and teaching building, with the average values of 14.79±9.15 Bq/m3, 22.67±5.72 Bq/m3, and 12.55±6.71 Bq/m3 respectively. The radon concentration in the student dormitory gradually accumulates as the test time is extended because it is conducted at night; the radon concentration in the teaching building is high and low because of a large number of personnel activities and the accompanying going to and coming from classes. During the whole testing process, the room is closed without strict limitation and the airflow in the room is not strictly controlled, so the test value only shows the normal indoor radon content.

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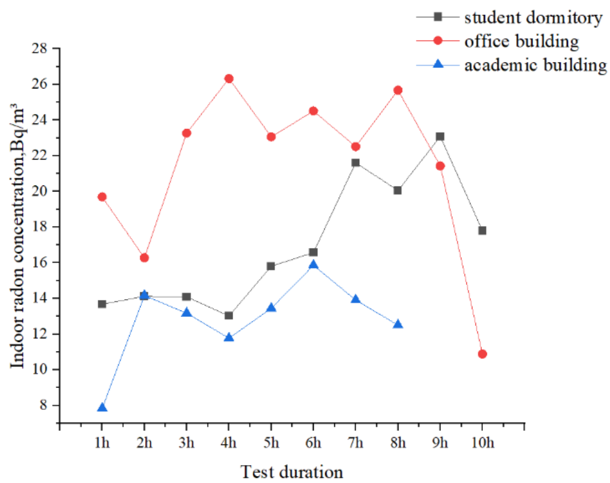

Fig.3 Indoor radon concentration in different buildings

3.4Different floors with indoor radon

The sources of indoor radon are mainly the building foundation, surrounding soil, and old building materials. When the building is above 3 floors, the contribution of soil radon can be neglected. It can be seen from Figure 4 that the indoor radon concentration gradually decreases on the 1st to 3rd floors due to the influence of soil infiltration; the indoor radon activity concentration gradually decreases on the 4th to 6th floors. The reason for this result may be that as the floor rises, the outdoor wind speed increases, and the ventilation rate increases, which leads to the decrease of radon activity concentration.

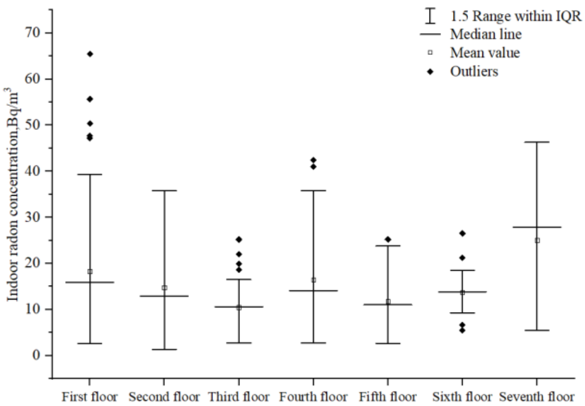

Fig.4 Indoor radon concentration in different floors

3.5 Temperature and humidity, number of air changes with indoor radon

In this paper, the relationship between indoor radon and temperature, humidity, and ventilation frequency was investigated by single-factor and Spearman correlation analysis. The results are shown in Table 1. It can be seen from the table that indoor temperature and humidity are positively correlated with indoor radon concentration, ventilation and air exchange are negatively correlated with indoor radon concentration, and ventilation and air exchange have obvious effects on reducing indoor radon concentration.

Table1 Results of Spearman correlation analysis

		indoor temperature	indoor relative humidity	air exchange frequency
indoor radon	related coefficient	0.131	0.167	-0.218
	conspicuousness	＜0.05	＜0.01	＜0.01

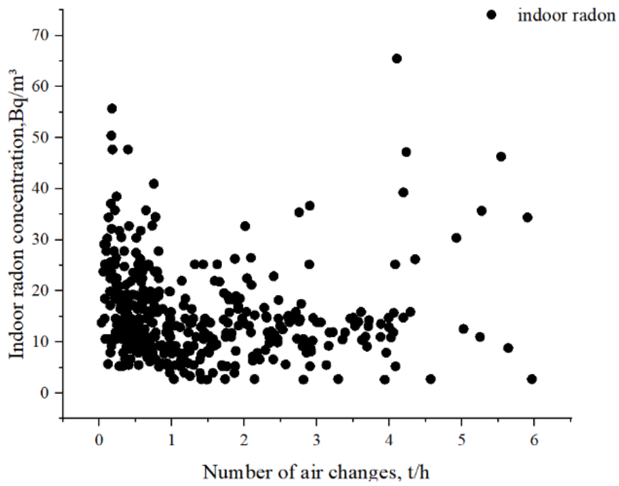

Fig.5 Indoor radon concentration in different air exchange times

The number of air changes is the main factor affecting indoor radon, and the average value is 4.6 times/h. It can be seen from the figure that the number of air changes is negatively correlated with indoor radon, of which about 1/2 is located in 0~1 times/h, which is because most people do not have the habit of opening windows for a long time; the number of air changes > 5 times/h but the indoor radon concentration is higher, probably because although the windows are opened for ventilation, more people cause the temperature to indirectly leads to the increase of radon concentration.

4. Conclusion

To investigate the harm of radon radioactivity to the human body, this sampling was carried out on campus. After this test, we got the following conclusions: (1) The indoor and outdoor air radon measurement data are lower than the limit value and also lower than the national average level of indoor radon; (2) Indoor radon has a positive correlation with indoor humidity and carbon dioxide, but a significant negative correlation with air exchange rate; (3) Through testing, indoor radon distribution and its influencing factors are explored, and guidance for improving indoor radon environment is proposed.

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