Detection and Analysis of the Concentration of Radioactive Radon in the Construction Environment of a University

Shuyi Chen*, Jinghui Gong, Letao Wan, Jingxian Chen, Yuan Dong, Yuan Yuan
School of Civil Engineering, University of South China, Hengyang, China

*Corresponding author e-mail: 1879527753@qq.com

Abstract. Radioactive radon is an important hazard in indoor air environments. In order to study the concentration of radon in the building environment, this paper tests the content of cockroaches in a university dormitory, teaching building and auxiliary room through experiments. And the experimental results are analyzed. The results show that: In the built environment, the closer the soil is to the foundation, the higher the concentration of radioactive radon, and the effect of temperature and humidity on the concentration of radioactive radon is very small.

1. Introduction
Radon is an inert natural radioactive gas that has the characteristics of long-term, concealed, harmful and difficult to completely eliminate. If it is not discovered in time, it will bring greater harm to people. In order to understand the distribution of radon concentration in the environment and its influencing factors, this paper experimentally tested the content of radon in the radioactive sites of the campus, such as dormitory, teaching building and auxiliary room. According to the test results, we analyze the environmental factors that affect the radon concentration, and propose corresponding treatment measures.

2. The basic properties and harm of radon
Radon is the product of radium (226Ra) and other radioactive materials. Radon gas is a colorless, odorless inert gas, is radioactive, and building materials are the main source of indoor radon [1].

Stone, granite, cement and other building materials contain radium. Once these materials are used in the construction of foundations, walls, floors, roofs, and so on, decay radon can enter the room. When a person inhales radioactive radon, the decay of radon α particles can cause radiation damage in the human respiratory system and lead to lung cancer. There are two main ways of harming human body by radon: external radiation and internal radiation.

2.1. External radiation
Radon brings less radiation damage in vitro, and its decay is mainly α-decay, but the ionizing effect of α-ray is large and the penetration ability is poor, so it is difficult to penetrate the skin of human body and can not cause great harm to human body. But it can still damage the body's hematopoietic organs, nervous system and digestive system.
2.2. Internal radiation
Radon is present in the air, it is easy to enter the body through the respiratory tract. When radon and its daughters enter the lungs through the respiratory tract, a series of radon daughters that decay will no longer be gases, but will be deposited in the lungs in the form of solid particles, where radon and its daughters decay in the body. The formation of fatal internal radiation to the human body can lead to lung cancer. High concentrations of radon also lead to changes in blood cells, radon has a high affinity for human fat, radon and nervous system after the combination of greater harm [2].

3. Current situation of social pollution of radon
The survey of 43000 houses in China shows that the national average radioactive radon content is 124Bq/m3, of which 21% are over 150Bq/m3, 5% over 400Bq/m3, 1.9% and over 740Bq/m3[3]. The radon concentration of underground buildings in Changsha reached 710Bq/m3, Hengyang, Hunan Province, Radon concentration in underground buildings up to 1080 Bq/m3.

4. Experiments text
In order to explore the relationship between the concentration of radioactive radon and environmental factors, the authors examined the concentration and ambient temperature and humidity of cockroaches in different teaching buildings, different floors, dormitories and auxiliary buildings in a university. The experimental results are shown in Table 1.

Table 1. Experimental Results.

| Time  | 12.1 | 12.1 | 12.1 | 12.4 | 12.3 | 11.30 | 12.2 | 12.3 | 12.3 | 12.3 |
|-------|------|------|------|------|------|------|------|------|------|------|
| Location | Teaching Building 1-103 | Teaching Building 1-205 | Teaching Building 1-311 | Teaching Building 1-410 | Teaching Building 2-110 | Teaching Building 3 | Infirmary | School | Supermarket | Dormitory | Dormitory | Dormitory |
| Concentration of radon gas (Bq/m³) | 33.33 | 6.67 | 6.67 | 10 | 33.33 | 110 | 60 | 20 | 16.67 | 16.67 | 13.33 |
| Temperature (℃) | 20.5 | 20.7 | 18.5 | 19.3 | 18.9 | 18.2 | 17 | 20.3 | 18.7 | 19 | 17.7 |
| Relative humidity (%) | 57.7 | 59.1 | 57.2 | 61.8 | 63.2 | 74.8 | 64.9 | 69.1 | 77 | 76.2 | 70.6 |

4.1. Distribution curve of radon concentration on different floors
The average concentration of radon in the soil is about 7400 Bq/m3, which is more than 1000 times higher than that in the surface air. Natural rocks and soils in nature contain natural radioactive isotopes such as uranium, thorium, radium, and potassium. The decay of helium produced by the decay of building floor cracks and wall cracks has become the main source of radon in the building[4]. What is the distribution of radon concentration at different heights from the ground? To this end, the author tested the average concentration of the first, second, third and fourth floors of the teaching building 1 on a certain day in winter.

The experimentally measured concentration curve of radioactive radon is shown in Fig. 1.

![Concentration of Radon gas](image-url)
As can be seen from the graph, as the number of floors increases, the concentration of radioactive radon gradually decreases. Since the first floor of the first floor is the closest to the soil and surrounded by large soil, the concentration of radioactive radon is the highest. The concentration of radioactive radon gradually decreases with the distance from the soil on the third floor of the second floor, but the door of the classroom on the fourth floor Facing the green belt of the corridor, the classroom on the third floor is far away from the corridor green belt, so the concentration of radioactive radon on the fourth floor is slightly higher than that on the third floor. From this it can be concluded that the closer to the soil, the higher the concentration of radioactive radon.

In addition, the author also tested the average concentration of sputum on the first, second and third floors of dormitory 1. On the west side of the dormitory, there is an outdoor flower bed with bare soil and tiles on the east side.

The experimental radioactivity enthalpy curve is shown in Fig. 2.

![Fig.2](image)

Fig.2. Radioactive radon concentration curve of the dormitory.

As can be seen from the graph, dormitory 105 is closest to the soil, with the highest average concentration of cockroaches, while dormitory 308 is the farthest from the soil and the average concentration of cockroaches is the lowest.

Therefore, it can be seen that in the built environment, the closer the soil is to the foundation, the higher the concentration of radioactive cesium.

4.2 Effect of temperature and humidity on the concentration of radioactive radon

To explore the effect of temperature and humidity on the concentration of radon in the environment, we measured the concentration of radioactive radon on the third floor of dormitory on November 22nd, 23rd, 25th, 26th, 28th, and December 4th, 2018. The experimental data are shown in Table 2.

| Time    | 11.22 | 11.23 | 11.25 | 11.26 | 11.28 | 12.4 |
|---------|-------|-------|-------|-------|-------|------|
| Concentration of Radon gas (Bq/m³) | 16.67 | 20    | 10    | 16.67 | 13.33 | 3.33 |
| Temperature (°C) | 15.1  | 14.7  | 16.5  | 17.3  | 17.7  | 18   |
| Relative humidity(%) | 73.2  | 67.2  | 68.8  | 71.2  | 70.6  | 54.8 |

According to the experimental data, based on the principle of least squares, MATLAB is used to linearly fit the temperature and humidity index with the concentration of strontium. The curve plotting the concentration of radioactive radon as a function of temperature and humidity is shown in Figure 3.
Fig.3 Radioactive radon concentration-temperature and humidity graph

From the graph, we can see that under the same humidity conditions, the concentration of radon changes little with the change of temperature. It can be considered that the influence of temperature on strontium concentration is small, which is negligible; Under the same temperature conditions, the concentration of radon increases with the increase of humidity.

5. Treatment of indoor radon concentration exceeding standard

Indoor radon concentration exceeding the standard should first find out the cause and take corresponding measures. Based on the experimental results, we conclude that the specific measures commonly used now are mainly as follows [5]:

(1) Separate the first floor from the surface soil. Because the concentration of radon is high in the soil, it can be separated by suitable building materials during construction to reduce the emission of cockroaches into the building.

(2) Natural ventilation. We should develop good living habits, often open the window to keep the indoor air clean. When the ambient temperature and humidity are too high, the air intake and exhaust equipment can be added to the naturally ventilated building; Buildings with centralized air conditioning systems can increase the amount of fresh air by increasing the design requirements for new air volumes.

(3) Reduce the use of geothermal water. In the domestic water use should reduce the use of underground hot water, in water, coal, gas should maintain indoor and outdoor effective ventilation.

(4) Strict selection of building materials. In order to reduce the release of radon to the indoor, the construction unit must strictly check the site selection, the use of building materials and decorative materials, and control from the source of pollution in order to reduce the release of radon to the indoor.

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