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Measurement of the Indoor Radon Concentrations in the School Auditoriums in Gyeongju

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1. Introduction

Radon is a naturally-occurring radioactive gas, which is produced by radioactive decays of radium found in trace amounts in all soils as well as building materials. Radon is likely to get into the buildings mainly through cracks in floors or gaps around pipes of cables.

The previous study shows that the risk of Radon is evident even at low-levels. Long-term exposure to high levels of radon can increase the risk of lung cancer. [1] Due to the health risk, the U.S. Environmental Protection Agency (EPA) has recommended the action level of 148 Bq/m^3. Korea has also referenced the U.S. EPA action level as the radon standard for the multi-purpose facilities since 2008, and has made the nationwide survey of the indoor radon concentrations periodically. [2, 3]

The city of Gyeongju has a lot of the historic heritages and then restricts the development and construction of new buildings as possible to preserve them. Hence, Gyeongju has the old buildings more than other cities in Korea. Also, Gyeonjgju has 4 nuclear power plants (NPPs) in operation, 2 NPPs under construction and a low- and intermediate-level radioactive waste disposal facility.

In this study, the indoor radon concentrations in the auditoriums of 23 schools in Gyeongju were measured.

2. Methods and Results

2.1 Measurement Locations

Fig. 1. The administrative districts in the city of Gyeongju.

The city of Gyeongju consists of 23 administrative districts: 4 Eups, 8 Myeons and 11 Dongs.

The school auditoriums to be measured were composed of sampling one auditorium in each district. The summary of the buildings to be measured in this study is shown in Table 1.

Table 1 Summary of the buildings to be measured

	Administrative area	School
1	Hwangseong-dong	Yonghwang Elementary School
2	Wolseong-dong	Seondeok Girls' High school
3	Yonggang-dong	Hwangsung Elementary School
4	Seonggeon-dong	Heungmu Elementary School
5	Seo-myeon	Ahwa Elementary School
6	Sannae-myeon	Uigok Elementary School
7	Hyeongok-myeon	Geumjang Elementary School
8	Cheonbuk-myeon	Cheonbuk Elementary School
9	Angang-eup	Sandae Elementary School
10	Kangdong-myeon	Kangdong Elementary School
11	Bodeok-dong	Seorabeol Elementary School
12	Naenam-myeon	Naenam Elementary School
13	Bulguk-dong	Bulguksa Elementary School
14	Oedong-eup	Oedong Middle School
15	Gampo-eup	Gampo Elementary School
16	Yangnam-myeon	Nasan Elementary School
17	Jungbu-dong	Wolsung Elementary School
18	Hwangnam-dong	Hwangnam Elementary School
19	Hwango-dong	Hwarang Elementary School
20	Seondo-dong	Gyeongju Middle School
21	Geoncheon-eup	Geoncheon Elementary School
22	Dongcheon-dong	Dongcheon Elementary school
23	Yangbuk-myeon	Yangbuk Elementary school*

* Yangbuk Elementary school did not cooperate. We could not do the experiment.

2.2 Experimental Procedure

The indoor radon concentrations were measured for 7 consecutive days using a RAD7 detector. The measurement procedure is as follows:

1) Before the measurement, the detector is purged for the 15 minutes;
2) The radon concentration of the radon concentration in the air outside the building is measured for the 5 minutes;
3) At measurement inside the building, the detector should be installed at the point which is in the center and 1.5 m high from the floor of the building;

4) At the measurement point, the measurement is continuously made for the 48 hours; and
5) If the measurement value of indoor radon concentration exceeds 148 Bq/ m^3 or is analyzed to be an abnormal value, the re- measurement is made and analyzed.

In the measurement of radon, temperature and humidity were also measured. Then in order to analyze the impact of other factors, building soil and age of building wer investigated.

2.3 Measurement Results

The measurements show that most of the measurement results did not exceed the U.S. EPA action level, 148 Bq/m^3. A part of the measurement results are shown in Fig. 2 and 3. This result seems to be due to the fact that the auditoriums are frequently used for students' sports activities weekdays and then well ventilated between inside and outside air.

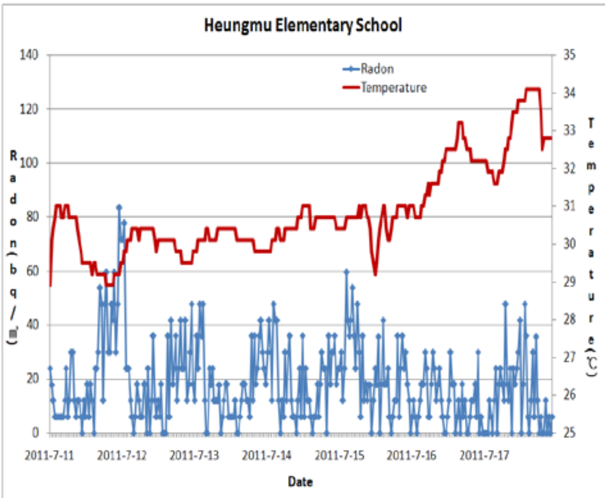

Fig. 2. The indoor radon concentration distribution for the auditorium of the Heungmu Elementary School with time. The average concentration is 18.30 ± 15.30 Bq/m^3.

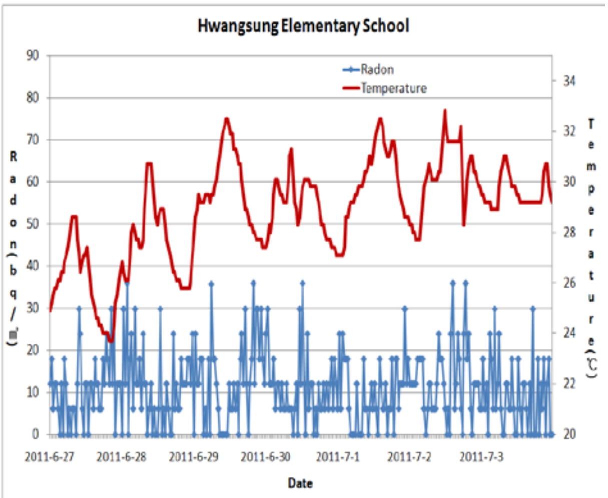

Fig. 3. The indoor radon concentration distribution for the auditorium of Hwangsung Elementary School graphs. The average concentration is 10.96 ± 8.77 Bq/m^3.

As seen in the Fig. 2 and 3, the indoor radon is almost in inverse proportion to the temperature. Temperature changes could cause change in the pressure and gas flow inside the auditorium and then finally affect the indoor radon concentration. So far, however, such a conclusion on the effect of temperature on the indoor radon concentration is a premature due to the insufficient measurement data. In order to identify the clear relation between two factors, a long-term measurement of radon concentration is needed.

3. Conclusions

The study confirmed that most of the measurement results did not exceed the U.S. EPA action level, 148 Bq/m^3. According to nationwide investigation of the indoor radon concentration by Korea Institute of Nuclear Safety (KINS), the average indoor radon concentration in Korea was 55.5 ± 56.0 Bq/m^3 [3]. From this, it was identified that the average indoor radon concentration in school auditoriums in Gyeongju were below the national average.

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