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Indoor air radon dose assessment for elementary, middle and high schools at Ulju county in Korea

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1. Introduction

Radon (referred ^{222}Rn in this paper) is one of the radioactive nuclide in nature, and it exists as the form of gas from decay of ^{238}U. Its half-life is 3.8 days and, it becomes stable ^{206}Pb after going through 4 alpha and 4 beta decays. Radiation by radon and its progenies occupies 43 % of total natural radiation, and it is considered as the one of the factors causing lung cancer. Therefore, it is one of the important issues of environmental radiation research since its danger has been known.

Ulsan is the largest industrial city and possesses the largest area among 7 metropolitan cities in Korea. Ulju county is one of the administrative districts of Ulsan, and covers over 70 % of Ulsan and is surrounded by mountain to the east and sea to the west, which has urban and rural area. Thus, there are many geological and industrial condition in its environment. Ministry of Environment (ME) of Korea is carrying out radon survey every 2 years, but this survey focuses on radon radioactivity of the houses and radon survey for schools isn't detailed.

At schools, people with various age work and are educated for a specific time, therefore, it is needed to analyze the radon radioactivity concentration of indoor air to estimate the effect by the radon exposure. In the present study, radon survey and dose assessment for Ulju county is carried out to secure radiological safety for the users of school facilities and to use the results for study to plan reduce radon exposure on the residents.

2. Methods and Results

In this section some of the techniques used to detect, survey indoor radon concentration and dose assessment for radon are described.

2.1 Radon detector

Alpha track which is one of the radon passive detector and developed by Rn-tech is used to survey indoor air radon concentration schools in Ulsan. Outline of Alpha track are shown in figure 1, and it is cylindrical with 4 cm diameter and 3 cm depth. It measures the time integral concentration of radon in air by solid state track detector (SSTD) LR-115 which is in the Alpha track. Some tracks are created on the surface on SSTD by the alpha particles emitted from the radon and its progenies, and its depth are about tens micro meters.

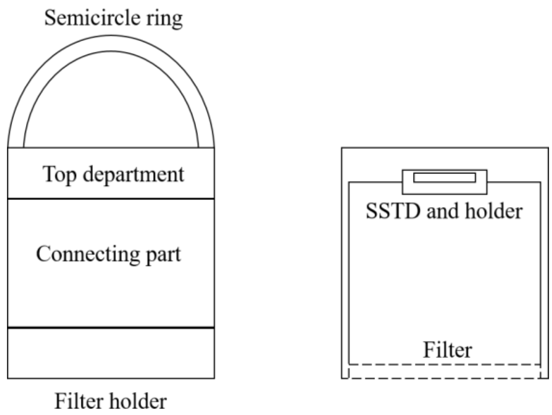

Fig. 1. Exterior(Left) and interior (right) structure of Alpha track.

These tracks isn't read easily as optical microscope, so it should be etched to enlarge the tracks by 10 ~ 25 % NaOH aqueous solution at a temperature 40 ~ 60 ° C during 1 ~ 6 hours to analyze tracks. Then, tracks can be read easily by the optical microscope or automatic readout system, and the average number of tracks in the unit area is converted to the concentration of radon by a conversion factor.

2.2 Survey design

57 schools in Ulju county was decided to survey indoor air radon concentration, and the number of elementary schools is 33, middle schools is 13, and high schools is 11. Total schools in Ulju county was 58 schools, and one school was excluded because it was in construction. Each detector is placed in two rooms of each schools during 3 months. After 3 months, placed alpha tracks are collected and sent to Rn-tech to analyze radon concentration of indoor air within 1 weeks. During the time between it was collected and sent, it was concealed to prevent additional radon detection. Survey are carried out during 3 season, which are summer, autumn, and winter. Thus, two factor seasons and kinds of schools are compared for indoor air radon concentration and average and standard deviation (s.d) are calculated.

2.3 Dose calculation for radon

Typically, a unit Work Level Month (WLM) was used for dose assessment of radon. WLM is “cumulative exposure from breathing an atmosphere at a concentration of 1 working level for a working month of 170 hours” as defined at ICRP 115 [2]. Working level is equal to 2.08 x 10^{-5} J/m^3, so WLM is calculated as 3.54 x 10^{-3} J h/m^3. It is calculated that 1 Bqm-3 of radon during 1 year causes 4.4 x 10^{-3} WLM at home with assuming occupying time is 7000 h per year [3].

The reference is not available to school because student at school has different occupied time with home, so school hour/year is surveyed for calculate WLM at the school for students.

There are many dose coefficient which are obtained from various epidemiological and theological study and range of dose efficient is 8-21.1 mSv/WLM. It this paper, reference of ICRP 6.4 mSv/WLM are used to conduct dose assessment.

3. Results and Discussion

3.1 Survey result

Survey results of radon for 57 schools at 3 seasons are presented in table 1. Increasing tendency is shown about average radon concentration from summer to winter, and it is calculated as 49 Bq/m^3. This increasing seasonal tendency are founded at previous research as well [4] [5]. Elementary schools are measured higher radon concentration than middle schools and high schools, and it is possible that elementary schools have more radon came from crack than middle and high schools because of older building.

Table I. Results of the radon survey for 57 schools during 3 seasons

		Elementary school	Middle school	High school	Overall
No. of schools		33	13	11	57
school hour / year		725	841	963	797
Radon concen. (Bq/m^3)	Summer	47	38	43	44
	Autumn	54	36	38	47
	Winter	66	39	40	55
	average	56	38	40	49
	s.d	44	14	18	36

3.2 dose assessment for radon

From survey data from table 1 and ICRP publication, dose assessment are conducted as table 2.

Table II. WLM and annual effective dose during school hour in schools

	Elementary school	Middle school	High school	Overall
Work Level Month (WLM)	0.0255	0.0201	0.0242	0.0245
Annual effective dose (mSv)	0.164	0.128	0.155	0.157

Even though elementary schools have low school hour per year, radon concentration of elementary schools are much higher than other schools, so effective dose from radon are calculated as highest value 0.164 mSv/year. Average radon concentration of middle schools measured similar level with high schools, effective dose from radon shows lower than high schools because of school hour / year difference.

Considering average annual effective dose of public by natural radiation is 2.4 mSv [6], calculated annual effective dose occupy small portion of total effective dose from natural radiation. The highest radon concentration was measured from one elementary school to 295 Bq/m^3, and annual effective dose was calculated to 0.861 mSv during school hour.

4. Conclusions

Indoor air radon radioactivity concentration and dose of 57 schools including elementary, middle and high schools in Ulju county were analyzed by using alpha track. It was understood that average radon concentrations of schools in Ulju county were being maintained below recommendation level although survey results of some schools showed 295 Bq/m^3 higher than regulation of Ministry of Environment for radon concentration, 148 Bq/m^3.

Indoor annual effective dose of 0.157 mSv by radon was found to be less than 7 % of the natural radiation exposure of 2.4 mSv when ICRP dose coefficient for adult male was applied. It was thought that further radon effect analysis for various ages including children was needed for more accurate dose assessment

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