#6077

International Symposium on Room Air Convection and Ventilation Effectiveness
University of Tokyo, July 22 – 24, 1992

Experimental Studies on the Influences of Indoor Airflow on the Characteristics of Radon Progenies

Koichi Ikeda
Dept. Arch. Hygiene & Hous. Eng.
The Institute of Public Health
4-6-1, Sirokanedai
Minato-ku
Tokyo 108, Japan

Michikuni Shimo
Dept. Nurc. Eng.
School of Eng.
Nagoya University
Furoucho
Chikusa-ku, Nagoya
Aichi 456, Japan

ABSTRACT

It is well-known fact that the behaviors of radon progenies, which are believe to be one of the major factors raising the lung cancer risk, are affected greatly by the characteristics of aerosols drifting indoor environments. It is considered that indoor airflow also has some effects on the radon progeny characteristics as well as the aerosols since the airflow raises the chance to encounter the radon progenies to the surfaces of walls, floors and/or ceilings. A few information concerning the airflow influences are, however, available so far. Measurements were made in the basement of an experimental house and in the tunnel of a soil movement observatory in order to investigate preliminarily how the indoor airflow affects the radon progeny behaviors. Although the degree of influences were less remarkable than the aerosols, indoor airflow do reduce the concentrations of radon progenies, especially that of the RaA which is electrically charged. The results suggest us a possibility to apply the airflow as a counter measure to reduce the radon progeny levels without relaying on ventilation which is very useful in the case of deep underground environments considered in the project developing very deep underground, such as fifty meters deep from ground level.

KEYWORDS: Aerosols, Airflow, Radon, Radon Progenies and Ventilation,

INTRODUCTION

It is well-known fact that the behaviors of radon progenies, which are believe to be one of the major factors raising the lung cancer risk, are affected greatly by the characteristics of aerosols drifting indoor environments. It is considered that indoor airflow has some effects on the radon progeny characteristics as well as the aerosols since the airflow raises the chance to encounter the radon progenies to the surfaces of walls, floors or ceilings. We have, however, a few information concerning the airflow influences so far.

Measurements were made in the basement of an experimental house and in the tunnel of a soil movement observatory in order to investigate preliminarily how the indoor airflow affects the radon progeny behaviors. We also studied the possibility of airflow as an effective measure to reduce indoor radon progeny levels.

OUTLINES OF THE EXPERIMENTS

Experimental Rooms Tested

Figure 1 shows one of the measured room which is a basement of the pre-fabricated timber flame experimental house. The measurement was made in November to December 1989, at a basement of the house. In walls of the basement, there are many holes of 5 cm diameter connected to underground soil through which radon gas can get in the room by removing the rubber stopper so that one may raise the indoor radon level.

The other room tested is a tunnel (Figure 2) for observing the soil movement in the suburbs of the Toyohashi, Aichi Prefecture, Japan. The experiment was conducted in May 1991.

Items Measured and Measuring Instruments

Aerosol concentration in the basement was measured by so-called "digital particle counter", or light scattering type particle counter. Radon gas concentration was measured by surface barrier type continuous monitor, and assumed equilibrium concentrations of both total and free, or unattached, fractions of radon progenies were determined by ZnS type continuous monitor with membrane and wire screen filters. Those measuring instruments were set close each other in a center of the room. Air flow near there was measured using hot-wire anemometer. Sampling period was one hour.

Aerosol concentration in the tunnel was, on the other hand, measured by so-called "Pollak counter", or condensation nuclei particle counter. Radon gas was measured with an ionization chamber and total and unattached fractions of radon progenies were sampled on membrane and wire screen filters and the concentrations of three progenies, RaA, RaB and RaC', were determined separately using semi-conductor type detector in this experiment. Those instruments were set near each other in a center of the tunnel and airflow of there was measure with hot-wire anemometer.

Ventilation rates in the rooms of both experiments were determined by tracer gas decay method using SF_6 gas as a tracer, concentration of which was analyzed by a gas chromatograph with electron capture detector.

Experimental Conditions

Both experiments were made in two level conditions, high and low, of airflow velocities and aerosol concentrations. The condition "low" means a condition often seen in a normal indoor environments. The condition "high" means a elevated condition by intentional additions of airflow and/or aerosols using a small fan and incenses.

RESULTS OF EXPERIMENTS

Effect of aerosol concentration on the radon progeny

1. Experimental house

Table 1 shows results of the experiment in the basement. All the values listed in the table are the averages over each run, which contains five to ten data obtained at the condition where the values were considered to reach their equilibriums.

As the radon gas emission rates were not controllable, indoor radon gas level of each run was changed much but felt into the range from 1300 to 3000 Bq/m^3.

The radon progenies levels are shown as "relative concentrations", or ratios of the progeny concentrations to the radon gas concentrations in this report since progeny levels are affected by radon gas concentrations which are uncontrollable and changed much as mentioned above.

The relative concentrations of total fraction of the radon progenies in normal "low" condition were 10 and 26%, while those in "high" aerosol condition were 37 and 44%, which were two to four times higher than in low condition. The relative concentrations of free, or unattached fraction of radon progenies in low conditions were, on the other hand, 0.8 and 1.4%, while those in high conditions were 0.3% or less, which are considerably lower than in normal. These facts are considered that electronically charged radon progenies just after disintegration were more easily captured by elevated level of aerosols, and that the facts are consistent to the findings made by many researchers, Shimo[1)] for instance, in the field of health physics.

2. Soil movement observatory tunnel

Table 2 shows results of the experiment in the Tunnel. All the values listed in the table are the averages of five to ten data which were considered to reached their equilibrium, too.

As the radon gas emission rates were not controllable also in this case, indoor radon gas level of each run was changed much but felt into the range of 2200 to 3200 Bq/m^3.

The relative concentrations of total fraction of the radon progenies in normal "low" condition were 44 and 58% for RaA, 25 and 28% for RaB, and 26 and 28% for RaC', while those in "high" aerosol condition were 95 and 99% for RaA, 72 and 75% for RaB, and 63 and 67% for RaC', which were two to three times higher than in normal condition. The relative concentrations of free fraction of radon progenies in normal conditions were, on the other hand, 25 and 26% for RaA, 1.9 and 2.8% for RaB, and 0.2 and 0.3% for RaC', while those in high conditions were 5.9 and 7.2% for RaA, 1.1 and 1.5% for RaB, and 0.2 and 0.5 for RaC'. Levels of RaA and B in high conditions are considerably lower than in normal. But those of RaC' in high are almost comparable to those in normal.

Effect of airflow on the radon progeny

1. Experimental house

Relative concentration of the total fraction of radon progenies reduced 15% (high aerosol condition) or 64% (low) by the change in airflow velocity from 0.1 to 1.5 m/s. On the other hand, relative concentration of the free fraction of radon progenies in the case of high aerosol concentration also reduced 40% by the change in airflow velocity although the tendency was not clear in the case of low aerosol concentration. These facts indicate that chance of plate-out of the progenies is raised by the increase in airflow. Airflow, in another words, has an effect reducing the radon progeny level. It may be considered the reason why such tendency was not seen in the case of free fraction of the progenies in high aerosol concentration is that there was not enough progenies in this case to show clearly the reduction in radon progeny concentration by airflow.

2. Soil movement observatory tunnel

The influence of aerosols on radon progenies in the tunnel was almost similar to the case of experimental house basement on the whole. Effects on the RaA revealed most clearly and those on RaB were almost same, while those on RaC' were just little bit different from other progenies.

DISCUSSION

Although ventilation is often deemed as the most passive and negative way since it allows the diffusion of the contaminants to indoors, it is the most effective and reliable way of removing indoor air contaminants, not only radon and its progenies but also all sorts of pollutants, from indoors. Ventilation is also one of the most available measure in most cases. There is, however, the case where ventilation does not get easily. The most probable case is service room of HVAC systems or such. Ventilation system in these places are often not prepared as they are considered as spaces without occupant. But in reality, these spaces are sometimes use by building maintenance staffs, such as HVAC engineers and janitors, for working and resting. The other ventilationless case is spaces in the deep underground, such as 50 meter or more, which is now investigating their realization in near future in this country.

The counter measures worth to consider the possibility of reducing the radon progeny concentration so far are;

1. to seal all cracks and openings of the room using vinyl sheet or such
2. to eliminate radon progenies with filtering equipments,
3. to increase indoor airflow in order to raise the possibility of settlement of the progenies to wall, floor, ceiling and/or other furniture.

First measure is the most effective way if the sealing is perfect. It is, however, required highly trained technics to accomplish and is the most expensive way. Moreover tremendous efforts are needed to maintain the initial sealing performance. It is sometime doubtful to be maintain really even if those efforts are made. Second measure is less expensive and therefore more realistic than the first. Third one is the most inexpensive and easiest way to adopt since it is necessary just to prepare small fan. However ability to eliminate the progenies may be the smallest. But it can be effective, especially in the case where the measure is employed with the second one.

CONCLUSIONS

1. The free fraction levels of radon progenies are decreased much by the increase of the aerosol concentration as already reported by many researchers[1].

2. The total fraction levels are, on the other hand, increased greatly.

3. It is considered that airflow has an effect reducing radon progeny level to some extent.

REFERENCE 1) M. Shimo: Investigation of Indoor Radon Progenies for evaluation of Lung Dose. Doctoral Thesis of Nagoya University, 1985

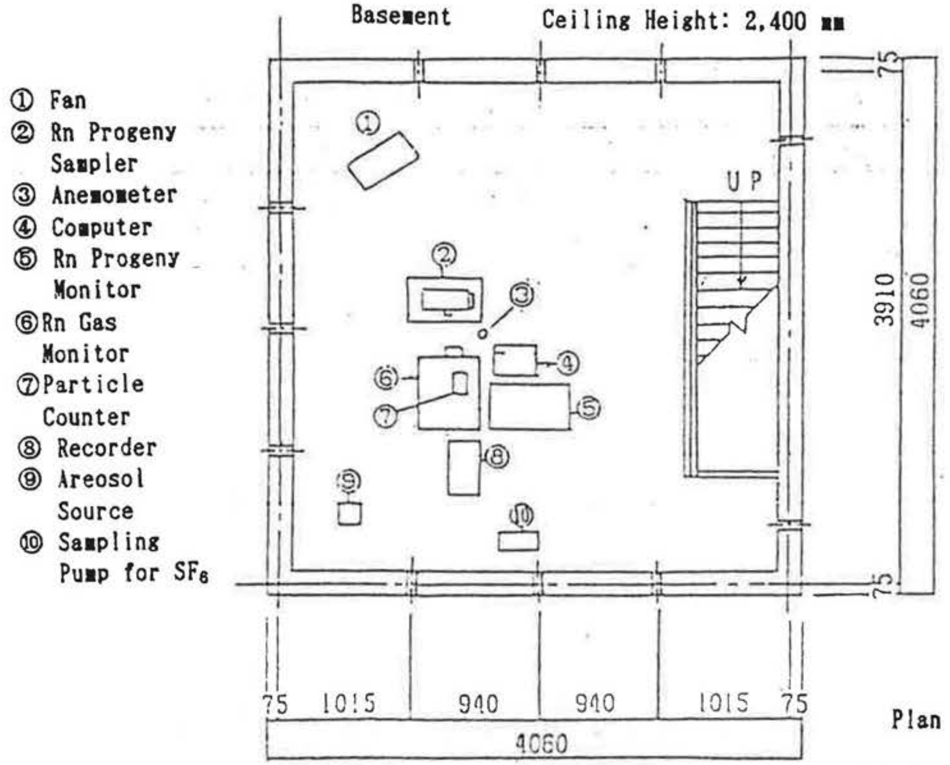

Figure 1 PLan View of the Experimetal House Basement
Dimensions in mm

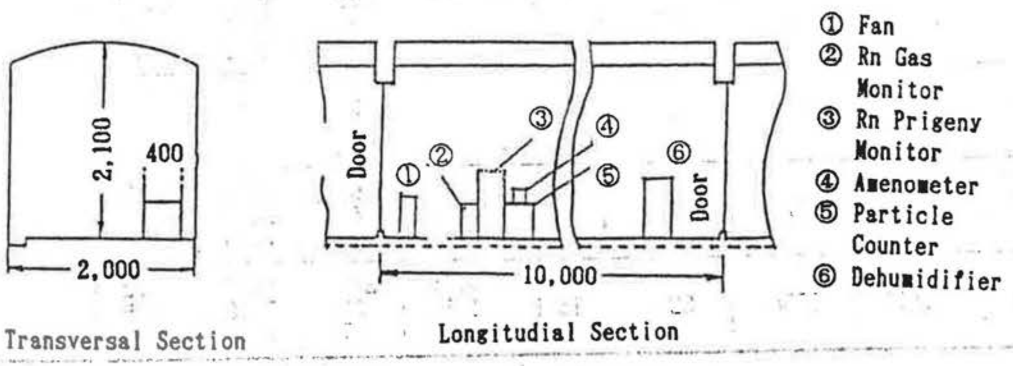

Figure 2 Section View of the Tunnel for Soil Movement Obervation
Dimensions in mm

Table 1 Results of Experiment in the Basement of Experomental House

Run	Exp. Conditions		Results					
	Air flow (m/s)	Areosol (mg/m³)	Radon Gas (Bq/m³)	Assumed Equilibrium Radon Progenies Concentration (Bq/m³)		Relative Concentration (%)		Ventilation Rate (h^{-1})
				Total	Free	Total	Free	
#1	0.09	0.030	1338	344	18.6	25.7	1.39	0.08[illegible]
#2	0.10	0.962	1825	807	4.9	44.2	0.26	0.098
#3	1.62	0.032	2150	295	18.1	9.5	0.84	0.066
#4	1.58	0.915	2977	1147	8.3	37.4	0.28	0.128

Table 2 Results of Experiment in the Tunnel of Soil Movement Observatory

Run	Exp. Conditions		Results						
	Air flow (m/s)	Areosol (particles/cm³)	Radon Gas (Bq/m³)	Radon Progenies Concentration (Bq/m³)			Relative Concentration (%)		Ventilation Rate (h^{-1})
					Total	Free	Total	Free	
#1	0.02	501	2201	Ra A Ra B Ra C'	1279 612 576	544 61 5	58.1 27.8 26.2	24.7 2.8 0.3	0.15
#2	0.02	5329	2486	Ra A Ra B Ra C'	2462 1867 1560	147 27 14	99.0 75.1 62.8	5.9 1.1 0.5	
#3	1.20	428	2196	Ra A Ra B Ra C'	969 542 610	565 41 4	44.1 24.7 27.8	25.7 1.9 0.2	0.23
#4	1.07	5564	3274	Ra A Ra B Ra C'	3076 2351 2205	237 50 7	94.7 71.8 67.3	7.2 1.5 0.2	