RADON INFLUENCE IN THE ESTIMATION OF BACKGROUND OF WHOLE-BODY COUNTING

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INTRODUCTION

Because of the existence of natural background radiation, it is important for the precise whole-body counting to keep the fluctuation of background radiation slightly. It is considered that radon and its daughters are one of the remarkable components of natural background radiation for its large fluctuation. Therefore, we investigated (a) the relationship of meteorological factors and radon concentration, (b) the effects of ventilation and filtration on radon concentration, and (c) the comparison between radon concentration and count rate of whole-body counter (WBC).

METHOD

1. Outline of WBC at the University of Tokyo

The WBC at the University of Tokyo is consisted of 20 cm thick iron shield room with 4 segments of 50x50x15 cm plastic scintillators and a 8inch ϕ x 4inch NaI(Tl) scintillator (1). Two ventilation systems are equipped; one is for an operation room (4.5m^3/min, air intake from top of the building, 21m height), the other is for an iron room (0.5m^3/min, air intake from the ceiling of iron room). The operation and iron rooms are situated at a semi basement floor.

2. Radon concentration measurement

Radon concentration was measured with PMT-TEL measurement system (provided by Pylon Co.) by the air-flow electrostatic sampling method. The air flow rate by the built-in pump was 2,000 cm^3/min. The radon concentration was averaged for 10 minutes or 1 hour. The conversion factor of count rate to concentration was 1.61 Bq/m^3/cpm from a reference manual of the system (2).

RESULTS AND DISCUSSIONS

1. Relationship between meteorological factors and radon concentration

The relationship between meteorological factors, which are temperature, humidity and atmospheric pressure, and radon concentration was investigated. As for atmospheric pressure, there was a significant correlation. Measured radon concentration level was low in case of higher atmospheric pressure. The regression equation was as follows:

$$RC = -0.270\ AP + 293$$

where RC is radon concentration (Bq/m^3), AP is atmospheric pressure (mb) (r^2=0.726). This tendency agrees with the previous report (3).

2. Effects of ventilation and filtration on radon concentration

Figure 1 shows the change of radon concentration in the operation room by the method of ventilation. When the ventilation was not operated, radon concentration reached about 40 Bq/m^3. In the case of air intake from the ground level, radon concentration remained at rather high level (about 20 Bq/m^3). When air was intake from the top of building with 21m height, the radon concentration was kept at low level (about 10 Bq/m^3). Under this condition, HEPA filter could not work to remove radon effectively.

As shown in Fig. 2, the ventilation of the operation room decreased radon concentration effectively and it took about 6 hours to settle a stable condition from the beginning of ventilation. This tendency has a good reappearance. The averaged radon concentration in the operation room was 8.5 Bq/m^3 in case of well-ventilation. The calculated value was 10.4 Bq/m^3, obtained by the following method.

The flux density of radon, J_D ($Bq/m^2/s$), from one side of a wall (or a floor) was calculated by the equation (4) shown below,

$$J_D = C_{Ra}\, \lambda_{Rn} f\, \rho\, [D_e / (\lambda_{Rn}\, \varepsilon)]^{0.5} \tanh d\, [D_e / (\lambda_{Rn}\, \varepsilon)]^{-0.5},$$

where C_{Ra} is the activity concentration of ^{226}Ra in the building element (Bq/kg); λ_{Rn} is the decay constant of ^{222}Rn ($2.1\ 10^{-6}$ /s); f is the emanation fraction, ρ is the density (kg/m^3); D_e is the effective diffusion coefficient (m^2/s); ε is the porosity, and d is the half-thickness (m). The ventilation rate is 4.5 m^3/min. The volume of an operation room is 197 m^3. Because air exchange through doors and other openings was not taken into account in this calculation, the actual amount of air exchange was larger. Therefore, the calculated value, 10.4 Bq/m^3, would be more small.

The comparison of the fluctuation of radon concentration in the iron room with/without ventilation of the operation room is shown in Fig. 3. The averaged radon concentrations per every ten minute were measured for 40 minutes. In the case of no ventilation, radon concentration was high (30 - 45 Bq/m^3) and its fluctuation was large. On the other hand, radon concentration was in low level and its variation was small. These results showed the air exchange between an operation room and an iron room could occur easily and only the ventilation of an iron room was not effective. Therefore, it is necessary and important to keep radon concentration in an operation room low by the ventilation of an operation room.

3. Comparison between radon concentration and count rate of WBC

The effect of radon concentration on WBC count rate with plastic scintillator is shown in Table 1. The count rate in the lower energy range below about 800 keV of WBC corresponded with radon concentration. The decreases of Bi-214 and Pb-214, which are radon daughters, by ventilation were observed in the spectrum measurement with a high-purity Ge semiconductor detector. On the other hand, there was no change of the count rate in the upper energy range above about 800 keV. That shows no consideration is needed in this high energy region on the discussion of radon influence.

CONCLUSION

The behavior of radon in WBC room was analyzed and the desirable condition of ventilation and filtration for whole-body counting was discussed.

REFERENCES

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4. United Nations, Sources and Effects of Ionizing Radiation, United Nations Scientific Committee on the Effects of Atomic Radiation, 1993 Report to the General Assembly, with Scientific Annexes, United Nations, New York (1993).

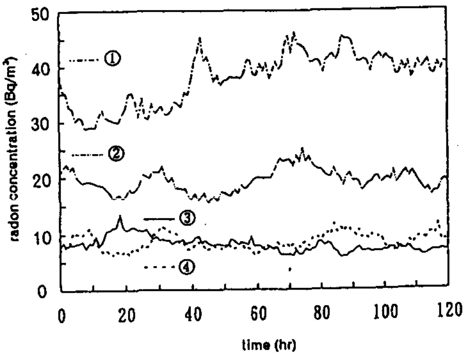
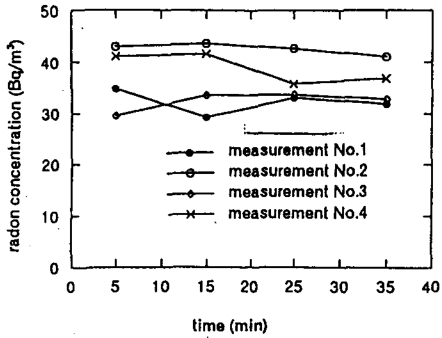


Fig. 1 Change of radon concentration by the method of ventilation; ① no ventilation, ② air intake from ground level, ③ air intake from 21 m height, ④ ③ through HEPA filter.



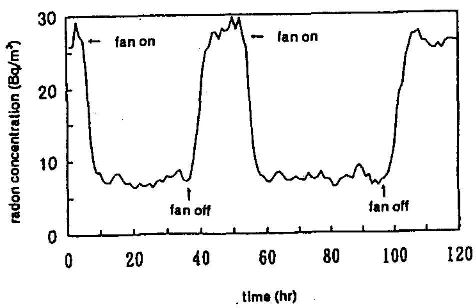


Fig. 2 Change of radon concentration with/without ventilation

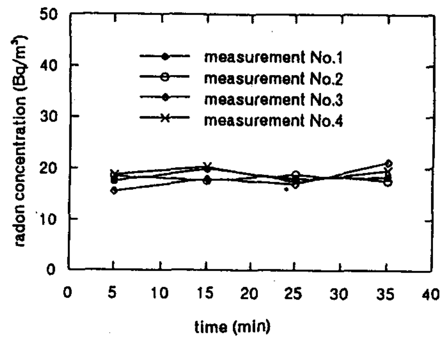


Fig. 3 Comparison of the fluctuation of radon concentration with/without ventilation

Table 1 The effect of radon concentration on WBC count rate

ventilation rate (m^3/min)	radon concentration (Bq/m^3)	WBC count rate (counts/10min) lower bin	upper bin
0	36.6 ±4.2	39286±293	11748±104
4.5	18.4 ±0.6	36894±182	11140± 95