MEASUREMENTS OF REGIONAL DISTRIBUTION OF ^{222}Rn CONCENTRATION and ANALYSIS ON OPTIMAL ALLOCATION OF MONITORING STATIONS

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ABSTRACT

Outdoor ^{222}Rn concentrations were measured with electrostatic integrating radon monitors (EIRM) at 40 points around Nagoya, in which fifteen sets of 2-month-exposure data over 2.5 years were obtained. Seasonal variation of ^{222}Rn concentration showed a clear pattern which had a spring-to-summer minimum and an autumn-to-winter maximum. Annual mean ^{222}Rn concentration ranged from 3.5 to 11.7 Bq m^{-3} depending on locations. From the obtained regional distribution of ^{222}Rn concentration, optimal allocation of measuring instruments was analysed. As a result, it was expected that the same concentration distribution could be obtained with less instruments.

INTRODUCTION

Measurements of regional distribution of ^{222}Rn (radon) concentration have been rare due to lack of proper detectors which enable us to conduct simultaneous measurements at many points for a long time. Information on the regional distribution of ^{222}Rn concentration and its time variation is important to study radon in relation to geological features, ^{222}Rn exhalation, and its behaviour in the atmosphere. Such information is also important to evaluate lung dose precisely. Based on such a background, measurements of outdoor ^{222}Rn concentration were implemented in an area around Nagoya to obtain its regional distribution and time variation.

INSTRUMENT

To measure the regional distribution in large area, monitors should be cheap and maintenance-free for a long time. To meet such demands, the most appropriate device will be passive monitors. In this study, we used electrostatic integrating radon monitor (EIRM) developed by Iida et al.[(1)]. It is simple and easy to handle, and can measure low-level

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outdoor ^{222}Rn concentration as its sensitivity is 20 times higher than cup method's.

The EIRM is a passive ^{222}Rn monitor, which accommodates a cellulose nitrate film and has electrostatic field in its interior to collect charged ^{218}Po. Tracks recorded on the CN films are enlarged by etching for 180 min at 60 °C in 2.5 N NaOH solution, and are counted through a microfiche reader. The lowest detectable concentration is 1.2 Bq m^{-3} for a 2-month-exposure.

MEASUREMENTS

The measurements were done in an area within 100 km from Nagoya University. Figure 1 shows the map of the area. The total number of monitoring stations was 40. EIRMs were settled at about 60 cm above the ground. In Nagoya City, the EIRMs were distributed in particular densely so that we could check the data consistency among nearby stations. The period of measurements was from August 1985 to January 1988 at half of the 40 stations, and from December 1985 to March 1987 at the other half. Results were obtained as an average of 2 month interval.

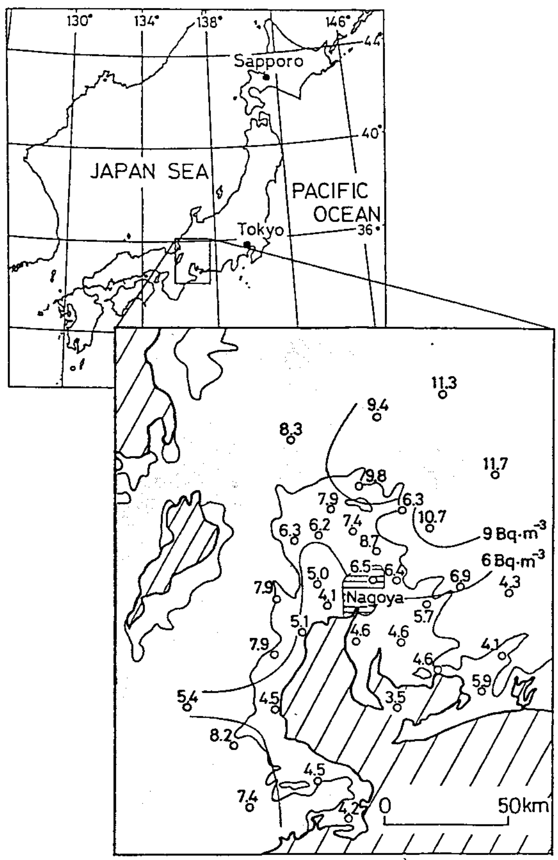

Fig.1 Map of ^{222}Rn measurement points around Nagoya and annual mean concentrations

RESULTS

The annual mean ^{222}Rn concentrations are shown in Figure 1. They scatter uniformly between 3 and 12 Bq m^{-3}. The areas of high and low levels correspond to mountainous regions and plains near the sea, respectively. The distribution patterns were nearly the same among the 15 periods while their levels differed largely. The ^{222}Rn concentration at each station was low from spring to summer, and high from autumn to winter. Amplitude of seasonal variations were between factors 1.2 and 2.8. In the mountainous regions, the mean ^{222}Rn concentration was high and fluctuated widely between 6 and 11 Bq m^{-3}. Near the sea, on the contrary, it was low ranging from 3 to 6 Bq m^{-3}.

In Nagoya City, the differences among stations fell within experimental uncertainty. This indicates that the concentration would be almost uniform within an about 10 km scale(2), if it is a plain with uniform geology.

OPTIMAL ALLOCATION OF MONITORING STATIONS

When we measure a regional distribution of atmospheric radon concentration, we must solve a problem how monitoring stations allocate. Methods of optimal allocation of monitoring stations have been developed in the field of air pollution monitoring. In the present study we looked for optimal allocation of monitoring stations with the view of measuring a regional distribution as precise as possible with limited measuring instruments.

For simplification of calculation, total area was segmented to "cell" that was a square of 6 km x 6 km. A concentration in one cell was regarded as uniform. A concentration of every cell was estimated with measured value of ^{222}Rn concentration by simple interpolation method.

It was regarded that a certain cell "x" represented cells which were within 25 km from it, and whose concentration differed from that of cell "x" within 1 Bq m^{-3}. Figure 2 shows reset stations and their representative areas. Each monitoring station is indicated by small circle, and its represented cells are marked the same alphabet as the station. If a cell belongs to several

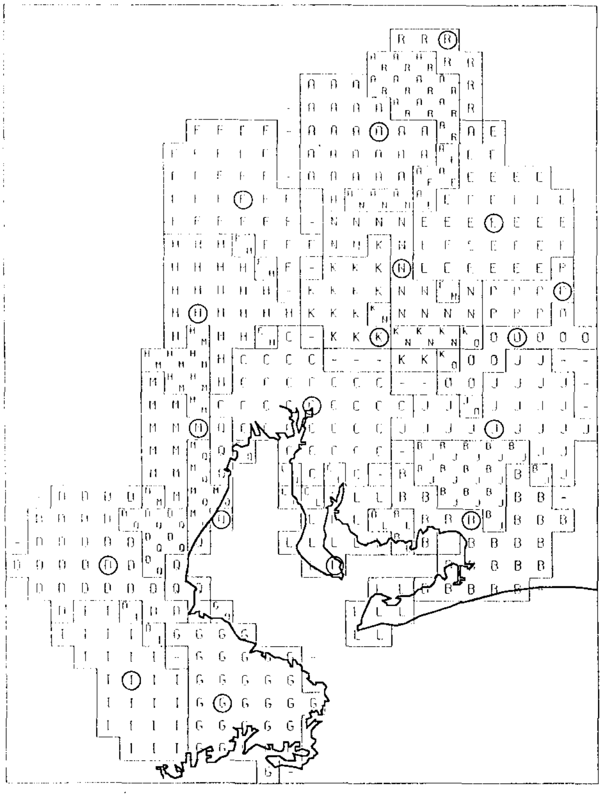

Fig.2 Allocation of monitoring stations and their representative area

representative area, it is put all alphabets of stations which occupy it. Summary process of the allocation is described as follows[3]. In the beginning, representative area was estimated for every cell respectively. The cell whose representative area had the most cells was chosen as the first station. The second station or subsequences was set at a cell which had the largest representative area as a result of subtracting overlap cells with the representative areas of the station set before. In consequence, imaginary monitoring stations were set alphabetically as shown in Figure 2. Eighteen sets of representative area cover 92 % area of all cells.

CONCLUSION

Regional distribution of ^{222}Rn concentration around Nagoya was measured with EIRMs. The concentration had a seasonal variation that it was low in spring-to-summer and high in autumn-to-winter. The level ranged from 1.9 to 11.7 Bq m^{-3} in spring, and from 2.3 to 18.9 Bq m^{-3} in autumn. Besides, the concentration was high and fluctuated widely in mountainous regions while it was low and varied to less extent near the sea.

Optimal allocation of monitoring stations was analysed with measured ^{222}Rn concentrations. By selecting new stations where have large representative area, it was expected that the same distribution of concentration could be obtained with the half stations than existing stations.

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