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CONTINUOUS MEASUREMENTS OF OUTDOOR RADON CONCENTRATIONS

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ABSTRACT The authors studied and developed an electrostatic ^{222}Rn monitor and have measured continuously outdoor radon (^{222}Rn) concentrations at Nagoya University since 1985. Four ^{222}Rn monitors were newly constructed to measure outdoor ^{222}Rn concentrations at other locations. The ^{222}Rn concentrations at Nagoya and Kasugai show a clear diurnal variation in autumn, and a seasonal pattern of a spring-summer minimum and a autumn-winter maximum. The results at Toki are the same pattern as that at Nagoya except spring. The concentrations at Kanazawa show a slight seasonal variation. A clear diurnal variation is observed in summer. (3 refs, 4 figs)

INTRODUCTION

To investigate radon (^{222}Rn) behavior in the atmosphere, continuous ^{222}Rn monitor which has following peculiarities is required: (1) a capability of measuring low ^{222}Rn concentration level continuously with high accuracy (2) a stable operation and (3) an easy maintenance. The authors studied and developed an electrostatic continuous ^{222}Rn monitor[1]. We have measured outdoor ^{222}Rn concentrations by using the monitor at Nagoya University since 1985. We have newly constructed four ^{222}Rn monitors and have measured outdoor ^{222}Rn concentrations at Kasugai, Toki, Kanazawa and Fuzhou. The present paper describes the construction and characteristics of the monitor and the some results for continuous measurements.

ELECTROSTATIC ^{222}RN MONITOR

Figure 1 shows the schematic diagram of the electrostatic ^{222}Rn monitor. The air flows into the 16.8L Al-hemisphere through a membrane filter and desiccators of phosphorus pentoxide (P_2O_5). Most of ^{218}Po atoms decayed from ^{222}Rn are positively charged[2]. The positive ^{218}Po ions are collected on the electrode of Al Mylar (0.9 $mg \cdot cm^{-2}$). Alpha-particles emitted from ^{218}Po and ^{214}Po atoms are detected with the underlying ZnS(Ag) phosphor of 10 $mg \cdot cm^{-2}$. The scintillation pulses are fed into a personal computer (NEC PC-9801RX) through the interface.

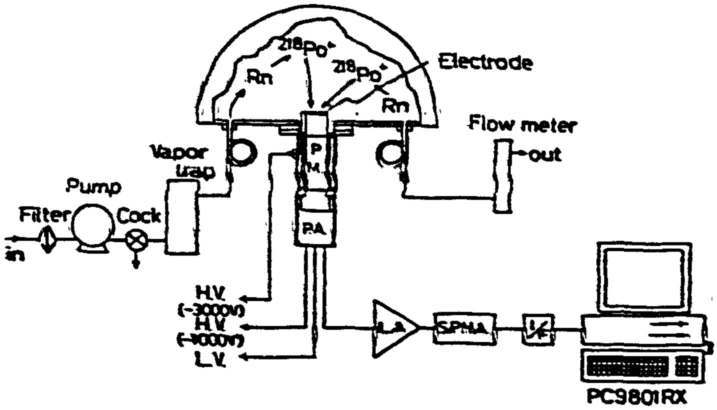

Fig.1 Schematic diagram of continuous electrostatic ^{222}Rn monitor.

The ^{222}Rn concentrations are calculated automatically from α-counts at one-hour intervals.

A flow rate was determined to 0.5~1 $L\cdot min^{-1}$, considering the exchange rate of the air in the monitor, the influence of ^{220}Rn in air and the amount of drying agent. The applied potential has been determined to be -3000V avoiding electric discharge. The efficiencies of four ^{222}Rn monitors are 0.308, 0.302, 0.299, and 0.319. The detection limits defined by Currie[3] are found to be 0.25, 0.32, 0.27 and 0.28 $Bq\cdot m^{-3}$, respectively. To compare the performances of the two monitors, we have measured outdoor ^{222}Rn concentrations for 5 months at a distance of 100m. The ^{222}Rn concentration levels and the diurnal variations obtained with two monitors agree precisely.

CONTINUOUS MEASUREMENTS OF ^{222}RN CONCENTRATIONS

We have carried out continuous measurements of outdoor ^{222}Rn concentrations since October 1990 at Nagoya and Kasugai in the plains, Toki in the mountainous regions and Kanazawa located near the Japan Sea. The distances between Nagoya and Kasugai, Nagoya and Toki and Nagoya and Kanazawa are about 10km, 30km and 150km, respectively.

Figure 2 shows the typical diurnal variations of ^{222}Rn concentrations in each season of 1991. The concentrations from 1 to 10 January showed almost the same variation at every locations. The ^{222}Rn concentrations during 3 and 7 January were very low. Most of the low concentrations correspond to the ^{222}Rn originated in China, since Japan was then covered with a cold air mass from the continent. The results from 21 to 30 April were low ^{222}Rn levels at every locations. The concentrations at Kasugai and Toki indicated almost the same diurnal variations as at Nagoya. The concentrations at Kasugai and Toki from 11 to 20 August were a little higher than that at Nagoya, since a south wind blows mainly in summer. On the other hand, the

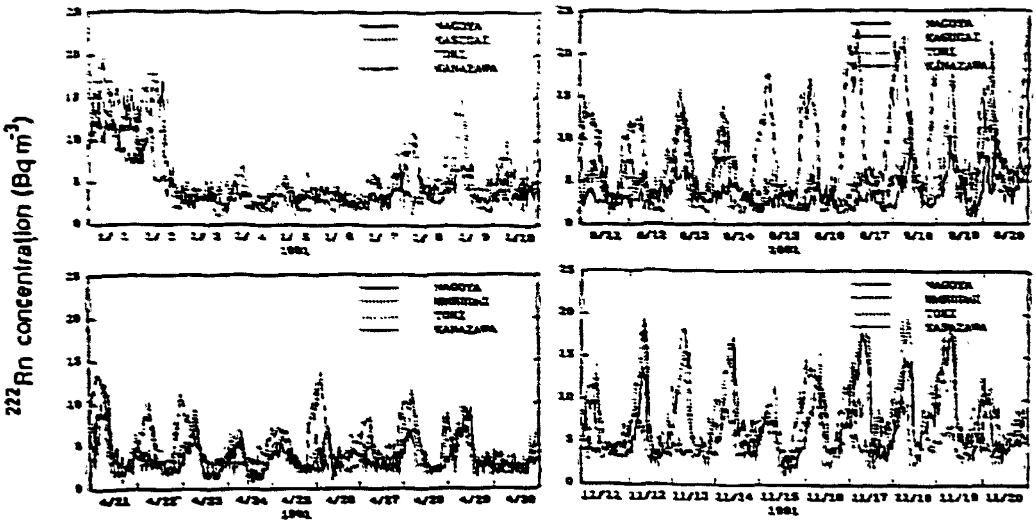

Fig. 2 Comparison of ^{222}Rn concentrations measured at Nagoya, Kasugai, Toki and Kanazawa in (a) Jan. 1～10, 1991, (b) Apr. 21～30, 1991, (c) Aug. 11～20, 1991, and (d) Nov. 11～20, 1991.

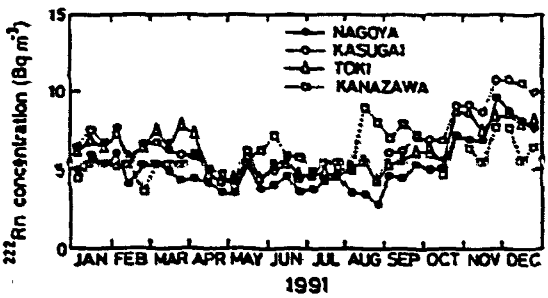

Fig. 3 Seasonal variation of average ^{222}Rn concentrations of every 10 days at Nagoya, Kasugai, Toki and Kanazawa in 1991.

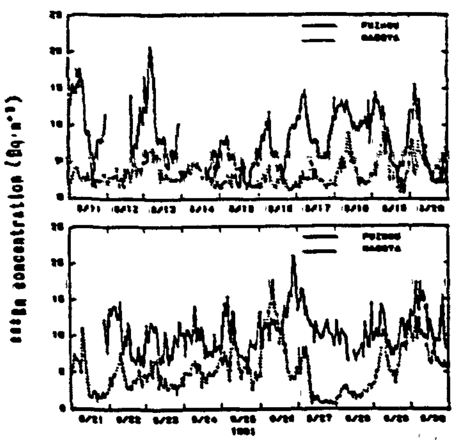

Fig. 4 Outdoor ^{222}Rn concentrations measured at Fuzhou in (a) Aug. 11～20, 1991 and (b) Sept. 21～30, 1991.

concentrations at Kanazawa showed large and clear diurnal variations. The results from 11 to 20 November showed that there are clear diurnal variations at Nagoya, Kasugai and Toki. The diurnal variation at Kanazawa becomes unclear and the mean ^{222}Rn level is low.

The mean ^{222}Rn concentrations every 10 days at each location are calculated to investigate the seasonal variations. The variations are shown in Fig.3. The mean ^{222}Rn level at Kasugai was a little higher than that at Nagoya. However, the seasonal variation of a spring-summer minimum and a autumn-winter maximum is almost the same as that at Nagoya. The mean concentration and the seasonal pattern at Toki are almost the same as those at Nagoya except March and April. On the other hand, the mean concentration at Kanazawa does not show a clear seasonal pattern. As described above, the high mean ^{222}Rn concentrations were observed in August.

We have measured outdoor ^{222}Rn concentrations at Fuzhou, China since July 1991. Figure 4 shows outdoor ^{222}Rn concentrations at Fuzhou in 11～20 August and 21～30 September, 1991. The results at Nagoya are shown by broken lines. The mean concentration and the diurnal variation at Fuzhou are very different from those at Nagoya.

CONCLUSION

From the characteristics of the ^{222}Rn monitor and continuous measurements of outdoor ^{222}Rn concentrations, it was proved that the monitor has a capability of measuring continuously low ^{222}Rn concentration level with high accuracy and stability. The ^{222}Rn concentrations at Nagoya, Kasugai and Toki show a clear diurnal variation in autumn. At Kanazawa, a clear diurnal variation is observed in summer. The diurnal variation at Fuzhou are very different from those at Nagoya.

In 1992, we set up three ^{222}Rn monitors at Matsue and Fukui in Japan and Beijing in China. We will continue to measure outdoor ^{222}Rn concentrations at every locations. The authors have developed the method of the numerical simulation for short-range and long-range ^{222}Rn transport. The ^{222}Rn concentration levels and the diurnal variations simulated at Nagoya agree well with the observed ^{222}Rn concentrations. This result suggests that it is possible to explain the variation of outdoor ^{222}Rn concentrations at every location.

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