Original

Measurement of Radon in Air Using the PICO-RAD Detecter and a Liquid Scintilation Spectrometer (2)

—Misasa district, Tottori pref. on sampling of 1993—

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(Received: 30 November, 1994)

ABSTRACT

A convenient radon detecting device for the purpose of estimating natural radiation exposure is described. The α radioactivity of its daughters originated from radon gas adsorbed in fine active carbon particles exposed to air is measured with a liquid scintillation spectrometer (Packard PICO-RAD system).

Its detection limit is 1.7 Bq/m^3 in air with an accuracy of about 10% on 200 minites of counting time, and correction coefficient, the ratio of measured radon concentration to standard radon concentration (about 300 Bq/m^3) is 0.75 on the standard radon gas chamber of Power Reactor and Nuclear Fuel Development Corporation. Radon concentrations at Misasa hot springs in Tottori prefecture were measured using the PICO-RAD method on 1993. They were 128~3,600 Bq/m^3 in a bath room, 25~45 Bq/m^3 outdoors and 28~89 Bq/m^3 indoors.

KEYWARDS

Radon, Liquid Scintillation Spectrometer, PICO-RAD, Misasa, in air

1. Introduction

The annual exposure dose due to natural radiation is around 2.4 mSv, varying with the location of residence and the environment. The exposure in the environment is predominantly due to the respiration of radon, followed by cosmic and terrestial γ-ray radiation and the intake of natural radionuclides.[1] Recently worldwide attention has focused on exposure due to natural radioactivities, especially radon and its daughters (including thoron).[1)-4)] Detection methods of radon are classified into sampling devices and durations, detectors and analyses etc..

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For sampling devices, there are several kinds of filter trapping methods, electrostatic trapping ones, active carbon trapping one, etc.. For detection instruments, there are liquid scintillation counters and nuclear track detectors etc.. These radon measurement methods are applied to the investigation of hot spring radiation exposure as well as earthquake forecasting. The behavior of radon and its decay products have also been widely studied.

We have adopted a simple and highly sensitive radon measurement method named the PICO-RAD system using active carbon adsorption vials manufactured by Packard Co. and a liquid scintillation spectrometer. Misasa Spa on Tottori pref. is one of the most highly radioactive hot springs in Japan and the water of which contains mainly ^{222}Rn. We have, measured the radon concentration in air and in water on sampling of 1993.

2. Methods

2.1 PICO-RAD System

The PICO-RAD radon detector as shown in **Fig. 1** is a vial containing an active carbon adsorber, the measuring proceduces of radon concentration in air.

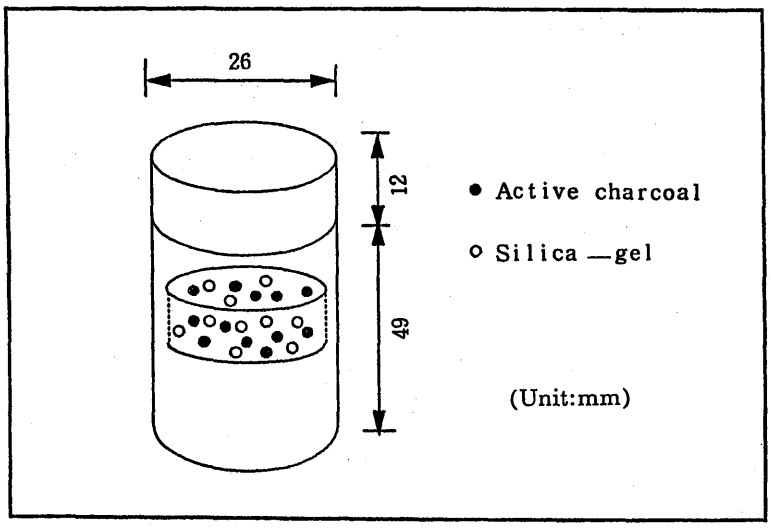

Fig. 1 PICO-RAD Detecter

(1) It is exposed to air for 12~96 hrs.
(2) The treatment of the exposed vial is sample.
(3) Humidity does no influence the calculating procedure because of the short sampling exposure time.
(4) It is light and of small size.

The Liquid scintillation counting procedure should be begun after complete radiation equilibrium. The radon survey of the hot springs in the Misasa area is as follows.

2.2 Sampling

Hot springs gush out at Misasa and Yamada along both banks of the Mitoku stream, the branch of Tenjin river flowing to the north in the middle of the Tottori pref.. We sampled the hot spring water along both banks of the Mitoku stream. **Fig. 2** shows radon sampling points on the Misasa area in Tottori pref..

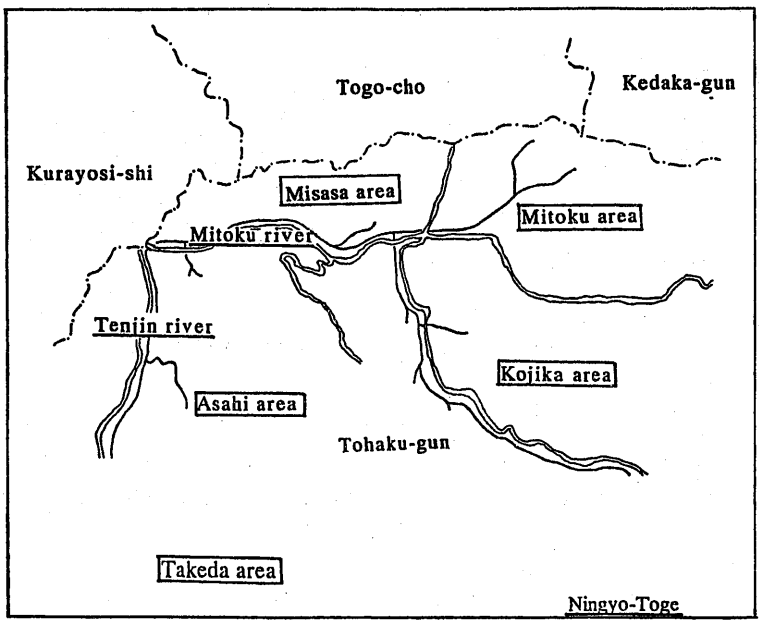

Fig. 2 Radon Sampling points on the Misasa area in Tottori pref.

2.3 Radon measurement

Radon measurements were done in water and in air (bath rooms, indoors, outdoors).

(1) The lid of the PICO-RAD vial was removed for 24 hours on radon adsoption, then ten milliliters of scintillator (INSTA-FLUOR) was poured into each vial. (2) After 10 mℓ of sampled water was poured into a 20 mℓ glass vial containing 10 mℓ of scintillator (OPTI-FLUOR), they were shaked for 30 seconds. These vials were brought to our laboratory and the radon concentration were measured with a liquid scintillation spectrometer (TRI-CARB 2250 CA Type).

2.4 Environmental radiation dose measurement

γ environmental radiation dose rates on Misasa district were measured using digital survey meter (Aloka PDR-101).

3. Results and Discussions

3.1 Characteristics of radon measurement using the PICO-RAD system

The measurement of radon concentration in air was made after radiation equilibrium.[5] The detection limit was determined from twice the standard deviation of the counts of

the PICO-RAD detector of which the lid was put on immediately after scintillator (INSTA-FLUOR) addition without exposure to air.

The detection limit of radon concentration in air was determined to be 1.7 Bq/m^3 on 200 minites of counting time. The relative standard deviation (accuracy) was estimated to be about 10%, which was derived from the counted value of the same sample replicated several times and the counted value of ten samples, respectively.

Correction coefficient (the ratio of standard radon concentration to the measured radon concentration) is 0.75 on 200 minites counting time 300 Bq/m^3 radon concentration in air on the standard radon gas chamber of PNC, when they are exposed for 24 hours.

This method has the following shortcoming. (1) Since the sample water is poured directly into the PICO-RAD counting vial, other α-emitting nuclides in the uranium series could be also counted. (2) Since the halflife of radon is short (3.824 days), the counting period after sampling is limited.

3.2 Radon concentrations in water and in air on the Misasa area

Radon concentrations in air on the Misasa area, Tottori pref. were summarized in **Table 1** and **Fig. 3.** Radon concentrations in air on November, 1993 were in the range at one meter on ground several~150 Bq/m^3 indoors and several~113 Bq/m^3 outdoors, respectively. These radon concentrations seem to be somewhat higher in comparison to the reference,[2] i.e. 19~130 Bq/m^3 indoors and 7~63 Bq/m^3 outdoors.

Table 1 Radon concentration in air on Misasa area, Tottori pref.

(Bq/m^3)

Sampling area	In bath room	Indoor	Outdoor	Indoor/Outdoor
Mitoku	—	6.5 ~12.2 (9.4±2.4)	4.0~7.1 (5.3±1.4)	1.8
Kojika	—	7.5 ~16.7 (11.3±4.2)	5.6~11.6 (8.3±2.3)	1.4
Asahi	—	16.5~145.1 (51.5±44.6)	10.0~112.2 (38.9±35.9)	1.3
Takeda	—	13.0~23.6 (18.3±5.3)	13.5~13.6 (13.6±0.02)	1.3
Misasa	127.5~3601.5	28.4~89.3 (54.1±22.4)	25.4~44.9 (37.0±7.4)	1.5
Higashi-Osaka (Control area)	—	2.1 ~16.0 (8.0±4.3)	0.62~11.0 (5.3±3.4)	1.6

Radon concentrations in air at Asahi district (Ogaki, Sakato and so on.) and Misasa spa were higher than the other. **Fig. 4** was shown radon concentration indoors and outdoors in Misasa area on map.

Radon concentrations in water and air on Misasa spa area were shown in **Fig. 5.** Radon concentrations in air were wide fluctuation in the range of 128~3,600 Bq/m^3, the bath room, 28~89 Bq/m^3 indoors and 25~45 Bq/m^3 outdoors. As the radon concentrations in hot springs were higher, the radon concentrations in air of the bath room were also higher. Radon concentrations in air were shown relatively good correlation with

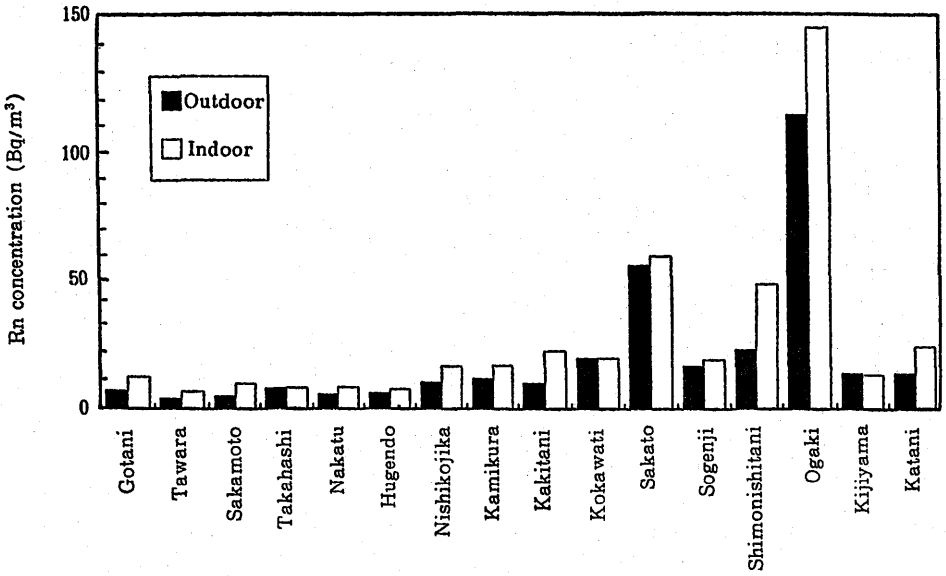

Fig. 3 Radon concentration in air on Misasa area, Tottori pref.

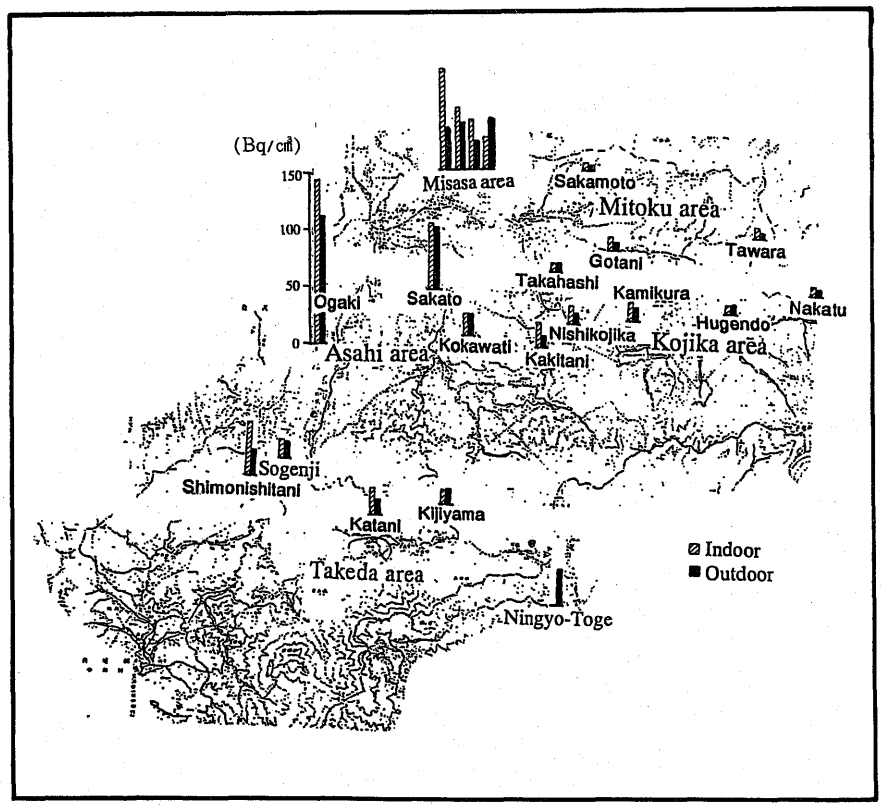

Fig. 4 Radon concentration in air on Misasa area, Tottori pref.

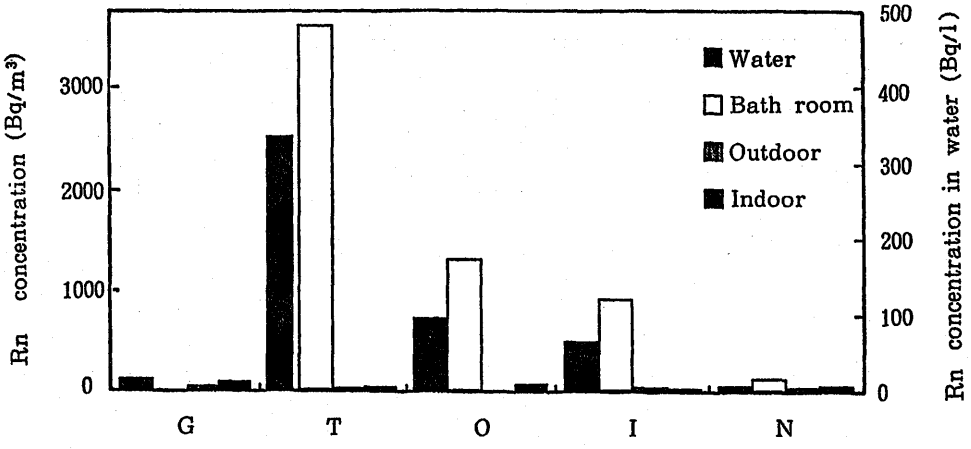

Fig. 5 Radon concentration in air on Misasa, Tottori pref.

radon concentration in source hot spring. Indoors and outdoors radon concentrations in the areas around Higashi-Osaka city were 8.3 Bq/m³ and 5.3 Bq/m³, respectively. The mean ratio of indoor radon concentration to outdoor concentration on Misasa area was 1.5 and the ratio on control area, Higashi-Osaka was 1.6.

The radon concentrations on this paper are corrected by correction coefficient of PICO-RAD method.

3.3 Environmental radiation dose rate

Environmental radiation dose rate on Misasa area were shown in **Fig. 6** using survey

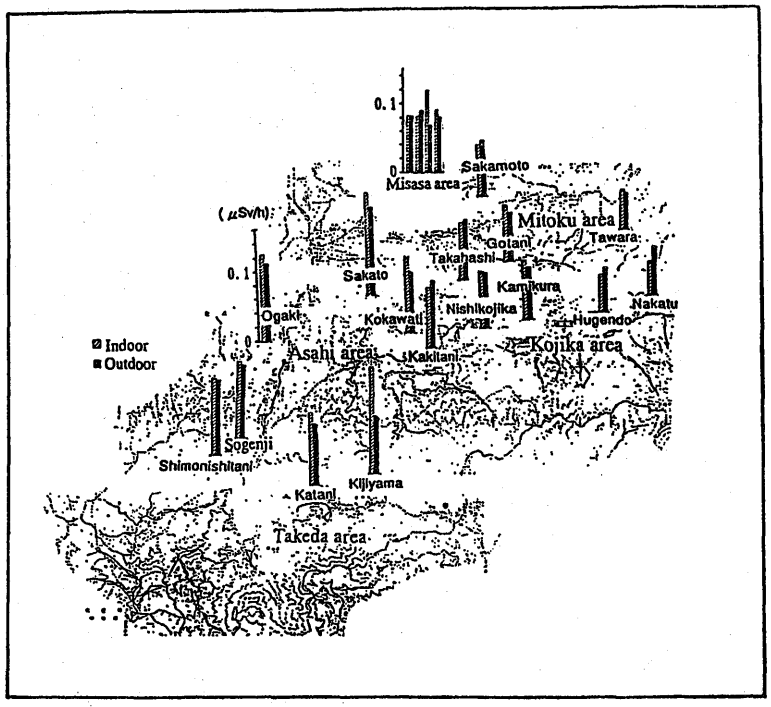

Fig. 6 Environmental radiation dose rate on Misasa area, Tottori pref.

meter (Aloka PDR-101). Mitoku and Kosika area were relatively low and Misasa spa, Asahi and Takeda area were a scarcely high. This exposure dose rate is good correlation with radon concentration in air. Because sample numbers are a small, we are going to pursue investigation in radon concentration determination.

4. Conclusion

Radon concentrations in air and in water at the Misasa district in Tottori prefecture were investigated on 1993 using the PICO-RAD system made by Packard Co. as follows.
1) Radon concentrations in bath rooms at Misasa spa area were 128～3,600 Bq/m^3, while outdoors they were 25～45 Bq/m^3, and indoors they were 28～89 Bq/m^3. These values are max. 15 times more than the values derived in control areas such as Higashi-Osaka city.
2) Radon concentrations in hot springs varied in the range of 7.8～323 Bq/ℓ.

ACKNOWLEDGEMENT

The authors would like to express their hearty appreciation for the standard radon correction and advice provided by Dr. S. Furuta, Dr. K. Ito et. al., Power Reactor and Nuclear Fuel Development Corporation.

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