

Nuclear Physics Methods for Determination of Radon in Water

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The results of the measured specific activities of Rn-222 in sewerage and drinking water of Ulaanbaatar City, Mongolia using the HP-Ge gamma-spectrometer, solid state nuclear track detector and liquid scintillator, are compared. The specific radioactivity for the Rn-222 in water of Ulaanbaatar City ranged 10-250 Bk/l, with an average of 110 Bk/l.

Introduction

Accurate determination of radon (Rn-222, half-life $T_{1/2}=3.8$ d) concentration in water is necessary in the fields of geochemistry and health physics. Radon and its short-lived daughter nuclide products are deposited in the lung which receives a dose from alpha radiation emitted during subsequent decays. As a result of such irradiation the lung cancer is perhaps provoked. In this paper the results of the specific radioactivity studies for Rn-222 in water measured by the HP-Ge gamma-spectrometer, solid state nuclear track detector and liquid scintillator, are described.

Materials & Methods

1. The method of HP-Ge gamma-spectrometer

Using the HP-Ge gamma-spectrometer the specific radioactivity of Rn-222 in water was determined by 295.21 keV and 351.92 keV gamma-rays from ^{214}Pb and 609.31 keV gamma-ray from $^{214}\text{Bi}^{(1)}$. Both of ^{214}Pb and ^{214}Bi are the radon's short lived daughter nuclides.

As a sample, 1000 ml water was directly poured in Marinel vial and a screw cap was tightly closed. The gamma-ray measurement of the water sample started about 4 h later for establishment of radioactive equilibrium between the radon and the short-lived daughter

nuclides. Measurement time was about 1 h. The detection efficiency was determined using the 2 different standard solutions made in the Amersham Co. (1996) and in the California (1994).

2. The method of liquid scintillator

Using the liquid scintillator analyzer (Packard) the specific radioactivity of Rn-222 in water was determined by 5.49 MeV alpha-particle from Rn-222, 7.687 MeV alpha-particle from Po-214 and 6.003 MeV alpha-particle from Po-218⁽²⁻⁴⁾. Both of Po-214 and Po-218 are the radon's daughter-nuclides.

The 40 ml scintillator was added to the 500 ml sample water then the flask was vigorously shaken and then kept for 4 h to separate the scintillator from the water phase. Finally, 20 ml of the scintillator-sample was transferred to glass vial and placed in the liquid scintillator analyzer which counts pulse of the alpha-particles.

3. The method of solid state nuclear track detector

For determination of the Rn-222 in water were used the solid state nuclear track detectors CR-39 ($\epsilon=95\%$)⁽⁵⁾ and TASTRAK. At first, we investigated so called equilibrium factor of these detectors used in the measurement. The detectors were exposed for 24 h with alpha particles of radon and its short lived daughter-

nuclides. Then, the detectors were chemically etched 200 ml solution (NaOH of 20%) at the constant temperature 70°C for CR-39 detector in 4 h and for TASTRAK detector in 12 h. The counting of the alpha-particle tracks were done with an optical microscope “Carl Zeiss”. From track density the equilibrium factors were obtained as $K=6.4 \cdot 10^{-2} [(Bk/l)/(track/cm^2)]$ and $K=7.2 \cdot 10^{-2} [(Bk/l)/(track/cm^2)]$ for the detectors CR-39 and TASTRAK, respectively.

Then, using the equilibrium factors the specific activities of Rn-222 in water sampled at different places of Ulaanbaatar City were determined as follows:

$$A = K \cdot \rho, [Bk/l]; \text{ where } \rho - \text{track density, } A - \text{specific activity}$$

Results and discussion

Comparisons of the results of measurements for the specific activities of Rn-222 in drinking and sewerage water using the HP-Ge gamma-spectrometer, solid state nuclear track detector and liquid scintillator are shown in Figs. 1 and 2. The results, also, are presented in table 1.

Dependence of the method of solid state nuclear track detector from the method HP-Ge gamma-spectrometer

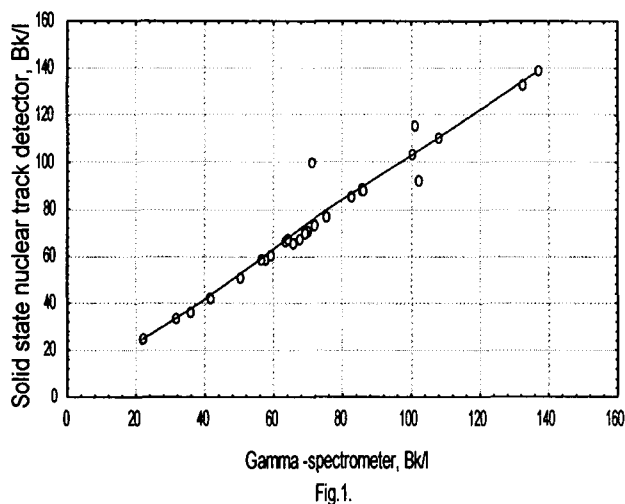


Fig.1.

Dependence of the method HP-Ge gamma-spectrometer from the method of liquid scintillator

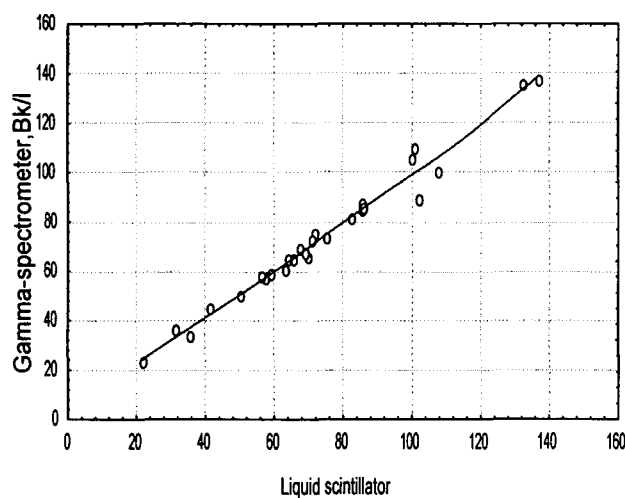


Fig.2

Table 1. The results of determination of specific activities of Rn-222 in water (Bk/l)

Number of samples	The gamma-spectrometer	The solid state nuclear track detector	The liquid scintillator
1.	107.2±6.7	103±5	105±7
2.	113.9±5.7	115±1	109±5
3.	90.3±2.6	92±4	88±7
4.	85.5±6.8	88±6	87±2
5.	107.7±5.6	110±4	112±6
6.	85.7±4.9	88±9	84±7
7.	21.8±2.4	25±7	23±6
8.	57.4±5.1	58±2	56±5
9.	71.6±7.6	73±5	75±7
10.	75.0±5.2	76±1	73±5
11.	63.4±1.3	66±4	60±9
12.	82.5±5.4	85±3	81±7
13.	65.4±6.7	66±7	64±8
14.	136.8±8.4	139±6	137±6
15.	69.8±4.6	70±4	65±4
16.	70.9±8.4	74±5	72±3
17.	59.1±7.1	60±6	58±7
18.	35.8±9.5	36±8	33±2
19.	50.3±5.1	51±1	50±5
20.	132.3±4.3	133±9	135±4
21.	31.3±3.3	33±5	35±6
22.	86.0±8.4	88±7	85±3
23.	64.0±7.5	67±8	64±2
24.	56.5±5.6	58±7	57±7
25.	67.6±9.4	67±6	69±5
26.	68.9±5.3	70±7	67±5

It has been seen that the results of measurements of the specific activities for the Rn-222 in water by three different methods are in agreement with each other. Measured specific activities of Rn-222 in water sampled at different places in Ulaanbaatar city, in April, May and June 1999, are presented in Fig. 3.

Thus, the specific radioactivity for the Rn-222 in water of Ulaanbaatar City ranged 10-250 Bk/l, with an average of 110 Bk/l.

It should be noted that standard level of the specific radioactivity for the Rn-222 in drinking water is less than 60 Bk/l and 100Bk/l in Russia and Australia, respectively⁶⁾. Therefore, we are planning to continue the study of the specific radioactivity for the Rn-222 in water using the HP gamma-spectrometer, solid state nuclear track detector and liquid scintillator.

Conclusions

It was shown that the methods of nuclear solid state track detector, HP-Ge gamma-spectrometer and liquid scintillator are suitable for determination of the specific radioactivity for the Rn-222 in water.

Using these methods the specific radioactivity of the Rn-222 in water of Ulaanbaatar City, Mongolia, was determined.

The specific radioactivity for the Rn-222 in water of Ulaanbaatar City ranged 10-250 Bk/l, with an average of 110 Bk/l.

References

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