การหาค่าสมมูลของก๊าซโทรอนโดยใช้แผ่นฟิล์ม CR-39

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บทคัดย่อ

งานวิจัยนี้เป็นการทดลองหาค่าสมมูลของก๊าซโทรอน โดยเทคนิคที่ไม่ซับซ้อน โดยการใช้แผ่นฟิล์มพลาสติก CR-39 ของบริษัท BARYOTRAK เป็นเครื่องวัดรังสี เทคนิคดังกล่าวนี้สามารถนำไปใช้ได้ทุกที่ พร้อมกับการใช้ปั๊มอากาศแบบใช้ไฟโดยตรง และถ้ามีการตรวจวัดความเข้มข้นของก๊าซโทรอนในพื้นที่ และพบว่ามีปริมาณก๊าซโทรอนสูงแล้ว จำเป็นต้องหาปริมาณความเข้มข้นของธาตุลูกหลานของโทรอนด้วย เพื่อใช้ในการประเมินถึงปริมาณรังสีที่มนุษย์ได้รับ และในงานวิจัยได้ใช้เทคนิคดังกล่าวในการหาค่าสมมูลของก๊าซโทรอนในบางพื้นที่ในจังหวัดภูเก็ต และพบว่าค่าสมมูลของโทรอนที่ได้ สอดคล้องกับค่าที่แสดงไว้ในรายงาน UNSCEAR ปี ค.ศ. 2000

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A Simple Technique for Determining the Equilibrium Equivalent Thoron Concentration Using a CR-39 Detector

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Abstract

The paper presents a simple technique for determination of the Equilibrium Equivalent Thoron Concentration (EETC). A solid-state nuclear alpha track detector (SSNATD) named CR-39 manufactured by BARYOTRAK is used as the detector. This technique can be utilized anywhere, provided that air sampling is carried out with a DC driving pump. Although the measurement of Thoron concentrations is useful enough for screening high Thoron exposure, it is still necessary to determine Thoron progeny concentrations in order to complete dose assessment. After applying this technique for determining the EETC in some selected polluted areas in Phuket Province, it has been found that the obtained EETC values are consistent with the values presented in the report compiled by UNSCEAR in 2000.

Keywords: Thoron, Equilibrium Equivalent, EETC, Progeny, Phuket

Introduction

Although a lot of studies on radon were conducted all over the world, there are a few studies on thoron. It is considered that doses from thoron progeny are generally smaller than those from radon progeny in the natural environment. Recent studies have shown that high thoron concentrations were observed in some particular areas, and the dose from thoron progeny is significant in these regions[1-3]. According to some recent study, occupational exposure to thoron progeny became significant and the protection against thoron progeny inhalation should be considered in the near future. In the case of radon exposure, the dose can be estimated by the radon concentration under several assumptions. The equilibrium equivalent radon concentration (hereafter called EERC) can be obtained by the product of radon concentration and equilibrium factor. On the other hand, it is impossible to follow the same procedure as the case of thoron exposure. The thoron concentration observed is exponentially decreased with a distance from the source for its short half-lift (55.6s)[4]. The use of thoron concentration will be meaningless unless the position of measurement is known. Therefore, the equilibrium equivalent thoron concentration (hereafter called EETC) should be directly measured from the viewpoint of the dose assessment.

Materials and Method

Figure 1 illustrates the experimental materials for alpha-track registration in this study. This easy technique can be utilized everywhere to determine EETC, due to following reasons; The sampling and measurement are completely separated.

1. The structure of the measuring system and its procedure are simple.
2. There is no limitation on electric condition when taking air samples and making measurement.

In order to satisfy the above conditions, a solid-state nuclear alpha track detector (SSNATD) which is typically used for determining EERC is selected as the detector. The CR-39 type detectors named "BAR-YOTRAK" which is commercially available in Japan were used in this study. Air samples were taken for 24 hours with a DC driving pump (flow rate 0.5 L/min), a glass microfiber filter (Whatman GF/F*) was used as the collecting medium. In order to determine thoron progeny concentration, the information on thoron progeny has to be distinguished from that on radon progeny. Therefore, the filter was left until radon progeny completely decayed, which usually takes more than 6 hours. An aluminum foil with the thickness of 15 μm (4.0 mg/cm^2) was then placed on the filter to reduce alpha particle energy emitted from ^{212}Po for effective detector. By placing a CR-39 detector directly on the filter cover with the aluminum foil for 2 days, registration of alpha tracks was subsequently made on the CR-39 detector. Following the manner of etching (chemically etched for 24 hr in a 6M NaOH solution at 60^{o}C) and reading number of tracks on the SSNATD, the thoron progeny concentration can be determined.

This technique was applied for determination of EETC in selected dusty areas in Phuket province. These included one indoor area and three outdoor areas.

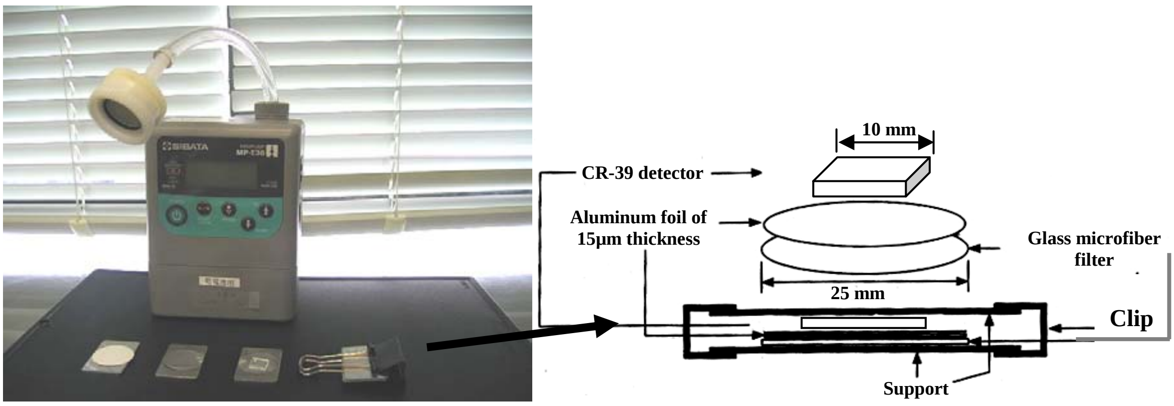

Figure 1: The experimental materials for alpha-track registration

Results and Discussion

Determination of the EETC[5]

^{212}Pb is the main measuring subject in the measurement system. The reason can be explained as follows: ^{212}Pb can be easily separated from mixed radon progeny because of its long half-life. Since more than 90% of EETC depends on the ^{212}Pb concentration; the EETC will not be overestimated even if the ^{212}Bi concentration is roughly assumed. The EETC can be approximately estimated from ^{212}Pb with the following equation:

$$EETC = 0.957 X_{Pb-212} \quad (1)$$

where

X_{Pb-212} = ^{212}Pb concentration [Bq m^{-3}]

The ^{212}Pb concentration can be determined by the following equation:

$$X_{Pb-212} = \frac{(N - N_{Bg})A}{I_{bc} \bullet \upsilon \bullet 0.2139} \qquad (2)$$

where

N = alpha-track density [mm^{-2}]

N_{bg} = background alpha-track density [mm^{-2}]

A = effective area of filter [mm^{2}]

υ = flow rate [m^{3} s^{-1}]

I_{bc} = the number of alpha tracks registered result from ^{212}Pb decay [Bq s]

I_{bc} can be calculated from below equation:

$$I_{bc} = \frac{\lambda_c}{\lambda_b^2(\lambda_c - \lambda_b)} e^{-\lambda_b T_w}(1 - e^{-\lambda_b T_s})(1 - e^{-\lambda_b T_m}) + \frac{\lambda_c}{\lambda_c^2(\lambda_b - \lambda_c)} e^{-\lambda_c T_w}(1 - e^{-\lambda_c T_s})(1 - e^{-\lambda_c T_m}) \qquad (3)$$

where

T_s = sampling period [s]

T_w = elapsed time after sampling [s]

T_m = measurement period [s]

λ_b,λ_c = decay constants of ^{212} Pb and ^{212}Bi, respectively.

The results of EETC carried out by these techniques in some dusty areas of industry located in Phuket province are summarizes in Table 1.

Table 1: The EETC in selected areas

Location	EETC (Bq.m^{-3})
Indoor	
Area 1	0.12
East Asia (6. UNSCEAR 2000)	0.03-1.8
Outdoor	
Area 2	0.15
Area 3	0.23
Area 4	0.07
East Asia (6. UNSCEAR 2000)	0.04-2.5

Conclusion

After applying this technique for determining the EETC in some polluted areas in Phuket province, it was found that the obtained EETC values are consistent with the values presented in the report compiled by UNSCEAR in 2000. This technique can provide unlimited use anywhere as long as air sampling is carried out with a DC driving pump. Although the measurement of thoron concentrations is useful for screening high thoron exposure, thoron progeny concentrations have to be determined, in any case, for dose assessment.

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