

DETERMINATION OF THE RADON EMANATION FRACTION FROM ROCK AND SOIL USING GAMMA-SPECTROMETRY

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A simple method for the determination of the radon emanation fraction from rock and soil was studied by a dual counting technique using gamma-ray spectrometry. Each rock and soil sample was sealed in a measuring container and measured two times by HPGe gamma-ray detector. The rock and soil sample was counted at 1 and 30 days after sealing the measuring container. The radon emanation fractions from rock and soil samples were estimated using radioactive equilibrium curves of radium (^{226}Ra) and radon (^{222}Rn). Eleven rock and seven soil samples were taken at the study site in which radon in groundwater was investigated. Mean radium concentrations in rock and soil samples were 64.5 and 99.5 Bq/kg, respectively. Mean radon emanation fractions from the rock and soil samples were 0.21 and 0.28, respectively.

I. INTRODUCTION

Radon (^{222}Rn) is a radioactive inert gas formed by the decay of radium (^{226}Ra) within the uranium (^{238}U) series. Radon has been recognized as a lung carcinogen by the World Health Organization and considered to be the major contributor to public exposure from natural sources. Most common radon concerns have focused primarily on indoor air radon that comes from soil and rocks surrounding the building foundation. In some cases, water radon might become a dominant source of indoor air radon. Based on data from a national survey on radon concentrations in groundwater wells (2,788 wells: 1,808 public water supply systems, 980 private water wells) in Korea during 1999 – 2012, 15 % of which were found to be above the US EPA's Alternative Maximum Contaminant Level (AMCL) of 148 Bq/L. In Korea Institute of Geoscience and Mineral Resources (KIGAM), various researches have been conducted to provide clean groundwater to residents in rural communities in Korea, where residents have used groundwater for all the life activities such as cook and wash in house as well as used it for agriculture and to breed livestock. In the present work, a simple and convenient method for radon emanation fraction was studied by gamma-ray spectrometry using dual counting techniques. Radioactive equilibrium curves of radium (^{226}Ra) and radon (^{222}Rn) were used to estimate the radon emanation fraction from 11 rocks and 7 soils at the study site.

II. GAMMA-RAY MEASUREMENTS

Soil and rock samples were collected at 15 points in the site (Imgok-ri, Sangju). Rock samples were crushed, sieved to the grain size of 150-2,000 μm and dried at room temperature to constant weight. The ^{226}Ra activity of the samples was measured by gamma-ray spectrometry. Each sample of around 250 grams were put in an aluminum measuring container and sealed with an epoxy resin adhesive. Radon activity was measured two times (4 and 30 days after sealing the measuring container; called dual counting in this paper) using an HPGe detector (Genie 2000, CANBERRA, US). The gamma rays of ^{214}Pb (295 and 352 keV) and ^{214}Bi (609 keV) were used for the ^{222}Rn activity analysis. Subsequently, the growth and decay curves of the radon concentration were plotted.

III. RESULTS

Radon emanation fractions (EF) from rock and soil samples were estimated using growth and decay curves of radon obtained from the dual counting. Because the half-life of ^{226}Ra (1600 year) is very much longer than that of ^{222}Rn (3.82 day),

secular equilibrium is reached around 30 days after sealing the measuring container. Radon emanation fractions (EF) could be estimated by following Eq (1) and Eq (2),

$$A_2^t = A_1^0(1 - e^{-\lambda t}) + A_2^0 e^{-\lambda t} \quad (1)$$

$$EF = \frac{(A_1^0 - A_2^0)}{A_1^0} \quad (2)$$

Where, A is activity of radon and radium (Bq/kg). λ is decay constant of radon. Subscripts 1 and 2 represent radium and radon, respectively. Superscripts are the times elapsed after sealing. Fig. 1 shows an example of the growing and decay curves for a rock sample (Rock type: shale, ^{226}Ra activity \cong ^{222}Rn activity in equilibrium condition: 80 Bq/kg, EF: 0.175).

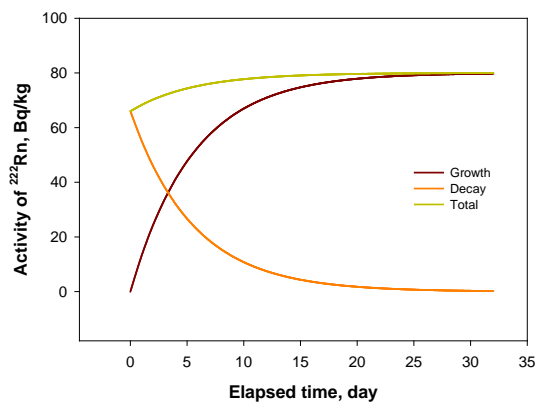


Fig. 1. Activity of ^{222}Rn with the elapsed time after sealing the measuring container.

IV. CONCLUSIONS

A simple and convenient method for the determination of radon emanation fractions from rock and soil samples has been studied by growth and decay curves of radon using gamma-ray spectrometry. The emanation fractions of radon could be used to study the sources of radon in groundwater.

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