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EFFECT OF SOIL AND SAND MOISTURE CONTENT ON RADON DIFFUSION USING PLASTIC TRACK ETCHED DETECTOR

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Abstract—Radon diffusion from soil and sand has been studied as a function of moisture content of soil and sand using plastic track etched detectors (LR-115 type II). It is observed that in soil and sand as the percentage of water is increased from dry state to 21% and 26%, respectively, a slow decrease in radon concentration (295 to 250 and 315 to 240 Bq/l) takes place; thereafter it reduces sharply to 27 and 50 Bq/l when soil and sand become saturated (25% and 40% water). The water-saturated soil and sand give the lowest concentration because of the much lower diffusion coefficient of radon through water.

1. INTRODUCTION

Radon isotopes are practically inert and have the properties of gases under conditions of geological interest. When a radium atom of mass number 226 disintegrates it yields an alpha particle and a radon atom of mass number 222. The atom is stripped of its outer electrons and expends its kinetic energy of recoil, of about 1×10^5 electron volts, along a track that is roughly 3×10^{-6} cm long in minerals of normal rock densities and about 6×10^{-3} cm long in air (Zimens, 1943). The neutral atom may then diffuse until it disintegrates or escapes from a mineral grain.

Quantification of the effect of moisture content on radon diffusion from different materials is of interest in radiation protection. Furthermore, it should contribute to an understanding of some micro-processes involved in radon migration and transport through ground. In this paper the results of a study of the influence of moisture content on radon diffusion through soil and sand using plastic track etched detectors (LR-115 type II) are reported.

2. EXPERIMENTAL TECHNIQUE

The plastic track etched detector (LR-115 type II) has been used to measure the moisture dependence of diffusion rate through different media, namely sand and soil. This detector can record integrated radon concentrations over specified time intervals and has already been calibrated in this laboratory using a 200 kBq radium chloride standard solution (Singh *et al.*, 1986). For the radon source, a uranium rich ore in powder form is used. A thick latex rubber membrane (Giridhar *et al.*, 1982; Ramachandran *et al.*, 1987) is used to protect the mixing of the source with diffusing materials (Fig. 1). An aluminium cylinder (4.5 cm diameter and 18 cm height) with a screw cap at one end is deployed vertically. This source constitutes the bottom of a vertical aluminium cylinder. This cylinder is then filled with the diffusing material up to a height of 12 cm, a space of 6 cm is left empty to avoid the impact of direct alpha particles. At the top of the cylinder plastic track detectors were fixed on an aluminium sheet (Fig. 1).

Homogenous soil and sand are kept under water for 48 h. Surplus water is removed and the weights are recorded. The cylinders are filled with water-saturated soil and sand. The plastic track detectors are fixed on the aluminium sheet at the top of the cylinder and the system is sealed and kept for 48 h at room temperature. The detectors are then removed, etched using 2.5 N NaOH solution at 60°C for 90 min and scanned in an area of 1 cm^2 to measure radon concentration. The relative uncertainty of track counting is reduced to less than 3% by increasing the area of counting (to 1 cm^2), and the error due to background (2.1 Bq/l in soil and 2.3 Bq/l in sand) is subtracted by repeating the experiment without the source.

After this initial experiment, the material is heated gently to reduce the moisture content and is then cooled to room temperature before it is weighed and enclosed in the cylinder to repeat the experiment. In this manner the moisture content is reduced step-wise and radon concentration was measured. Finally, the material is heated at 150°C for 24 h to make it dry.

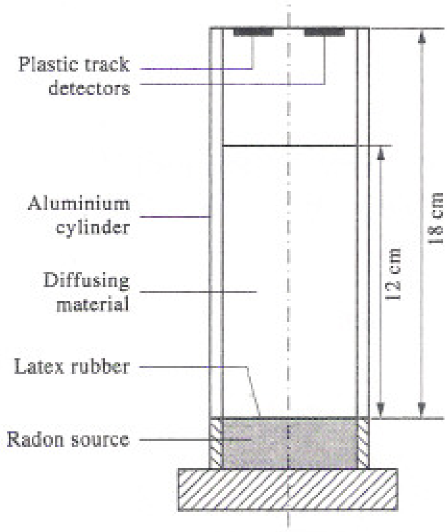

Fig. 1. System used to measure radon diffusion using a plastic track detector.

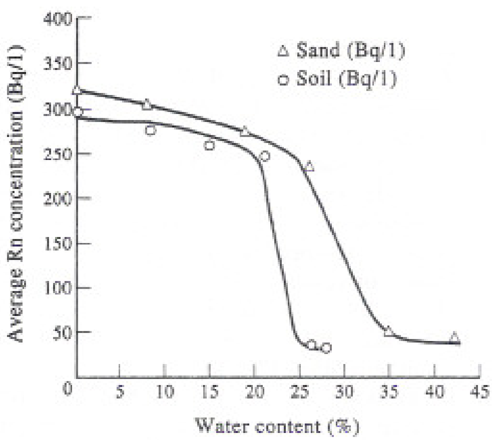

Fig. 2. The variation of radon concentration with soil and sand moisture.

3. RESULTS AND DISCUSSION

The variations in radon concentration with water content for soil and sand are given in Fig. 2. The experimental results in soil indicate that as the percentage of water is increased from dry state to 21%, a slow decrease in radon concentration (295 to 250 Bq/l) takes place, thereafter it reduces sharply to 27 Bq/l when the soil becomes saturated (25% water) (Fig. 2).

The variation in radon activity in sand with water content indicates that as the percentage of water is increased from dry state to 26%, a slow decrease in radon concentration (315 to 240 Bq/l) takes place, thereafter it reduces sharply to 50 Bq/l when the sand becomes saturated (40% water) (Fig. 2).

The diffusion coefficient in water is about $1.97 \times 10^{-4}\ cm^2\,s^{-1}$ compared to that in air which is $2.10 \times 10^{-1}\ cm^2\,s^{-1}$ (Tanner, 1964). So, radon diffusion will be much slower when the pores are completely filled with water. When internal pores become saturated and the free water appears in the interstitial spaces between particles, the diffusion coefficient is markedly reduced. The reduction in radon flux varies according to the percentage saturation of interstitial voids.

4. CONCLUSIONS

The diffusion rate in soil and sand is found to decrease with increase in moisture content and is lowest near the saturation state.

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