MONITORING RADON CONCENTRATIONS IN RESPIRABLE AIR

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Abstract

The radon-daughters present in air were collected on filters for different length periods. The determinations of separate alpha activities were done by using a silicon semiconductor aetector and by the etch-foil technique. The differences between these techniques, including their feasibility and calibration, are described. Finally, some measurement results are discussed.

INTRODUCTION

In addition to the great interest given to radiation workers who inhale radon and radon-daughters in uranium and fluorspar mines, German authorities have begun to take an interest in the radiation doses received by the general public by desiring to measure the concentrations of radon and radon-daughters in the air of their dwellings.

The aim of this work is to prepare simple and inexpensive instruments for routinely measuring exposures to radon-daughters.

We decided to collect radon-daughters on diaphragm filters because they are inexpensive, can be used at a high-speed, and allow for the continuous measurement of alpha activities. A simple maintenance-free diaphragm pump is used to produce a constant air flux. The sampling period must be long, due to the relatively long half-lives of the radon-daughters, in order to get a stable ratio effect on the filter measurements. We used a silicon semiconductor detector and the etch-foil technique to measure the alpha activities of the radon-daughters.

SILICON SEMICONDUCTOR DETECTOR

The silicon semiconductor detector, or surface barrier detector, we used counted impulses with a single-channel analyzer. The lower and upper trigger-levels were set to exclude beta and gamma radiation — as well as pulses due to ThC' alpha particles. We were able to keep the bias from thorium-daughters at a negligible level.

The detector we used has a sensitive surface of 400 mm^2, which is covered by a protective foil. The distance between the filter and the detector surface we used was 5.2 mm. With this geometry, the counting efficiency is about 0.20 without allowing for the self-adsorption in the filter. A constant air flux of 1265 1/hr was used for continuous monitoring.

The potential alpha energy concentration was measured in units of MeV/1, or in WL, as the potential alpha energy concentration is very important for the estimation of dose.

Due to ventilation, variable aerosol concentration, and plate-out on the wall surfaces, there is no radioactive equilibrium in closed rooms. Therefore, disequilibrium factors must be taken into account while measuring potential alpha energy concentrations of single decay products by count rate in room air. In practice, the proportionality between counting rate and energy concentration is sufficient (Jacobi, 1972).

A sensitivity of 28 Imp/hr for 1 MeV/1, or 37.2 x 10^5 Imp/hr for 1 WL, results for the counting apparatus when filter efficiency, detector efficiency, and the activity distribution in the air and on the filter is taken into consideration.

Accordingly, the definition of the working level has the same counting rate as in the case of radioactive equilibrium and 100 pCi/1. The high sensitivity of this measuring system allows the measurement of daily variations of alpha energies in the room atmosphere to be made in only two minutes.

Figure 2 shows the course (curve) of the potential alpha energy concentrations in a living room over 24 hours. On this day, there had been warm and sunny weather.

Figure 3 demonstrates the course (curve) of this same room on a rainy day. These examples show the big influence weather has on energy concentrations in a room.

The measuring range of the mentioned air flux is 10^{-5} -10 WL. Higher concentrations can be secured by restricting the air flux; however, they cannot be expected to be in the applicable range. With an integrated indication of the pulse counter, which is equal to a prolongation of the measuring time from 2 minutes up to the measuring time in question, the radon-daughters exposure can be read.

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The semiconductor method can easily be employed for continuous and long-term measurements. Unfortunately, the silicon semiconductor detector is too expensive for routine wide-scale use — as is a requirement in our work. Purchasing several of these detectors, which would be needed by the surveyor teams, would be prohibitive.

ETCH-FOIL TECHNIQUE

After we decided the silicon semiconductor detector was not feasible economically for our purposes, we experimented with an etch-foil technique using a plastic foil. With this technique only a small diaphragm pump with variable air flux was needed together with a gas counter and a filter-foil holder. These items are all inexpensive to purchase or fabricate.

After reaching the stable (stationary) state during the time of interest, the alpha activities collected on the diaphragm-filter are measured by counting the tracks produced on the foil. The result is the time integral of the potential alpha energy concentration. In order to get an average (or mean value) for the whole day, a 24-hour measurement is taken.

Cellulose-nitrate is a good detector foil because of its high sensitivity to alpha particles. Since the necessary thickness of 15 micrometers for this plastic foil is not available in Germany, it must be produced by centrifuge as recommended by Paretzke (1972).

Even though an accurate visual counting of the tracks can be done by microscope, the analysis is made by the spark-counter. The spark-counter allows the routine use of this method.

The measurement sensitivity of this system using a detector surface of 850 mm^2, a filter, and an air flux of one 1/hr equals 0.8 tracks per MeV/1 x hrs., or 10^5 tracks per WL x hrs. This sensitivity results when the detector foil and filter are 5 mm apart and a 20 micrometers thick absorption foil is used.

SURVEY MEASUREMENT RESULTS

Preliminary results show alpha energy concentrations in living rooms have the same temporal variation as outdoors. This means that the concentration inside is directly affected by the concentration outside. Very low values were found in rooms like concrete cellars, which are relatively independant of outdoors. Apparently there is no correlation between building materials and alpha energy concentrations, for no significant differences were found in buildings made of concrete, brick, or gypsum. The only exception to this that we found was in the case of granite and new uraniferrous red sandstone buildings where the measurements showed somewhat higher concentrations of alpha energies.

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Semiconductor System:	$28 \frac{Imp}{h}$	for $1 \frac{MeV}{l}$
	$37 \times 10^5 \frac{Imp}{h}$	for 1 WL
Solid State Track Det. System:	0,8 tracks	for $1 \frac{MeVh}{l}$
	10^5 tracks	for 1 WLh

Figure 1. Sensitivity of the Filter Method.

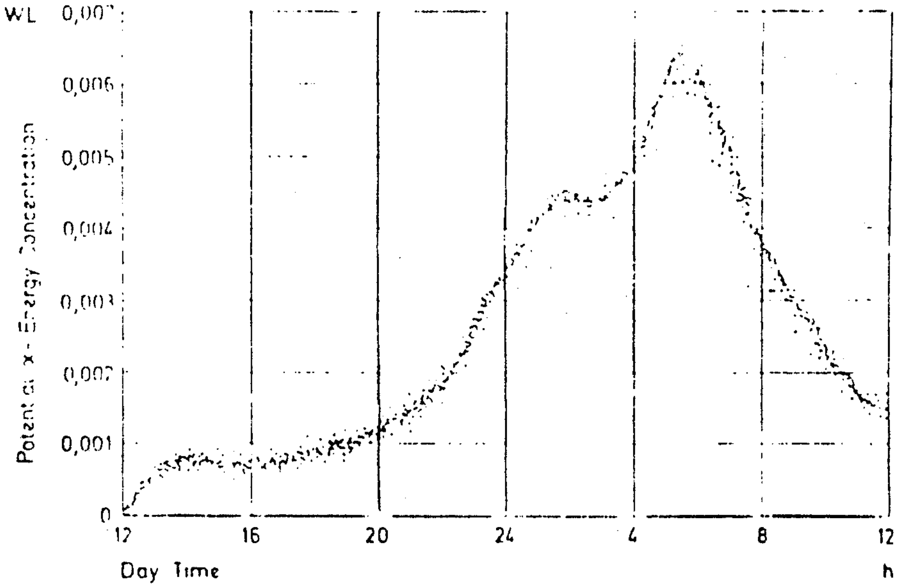

Figure 2. Daily variation of the potential a-energy concentration during 24 h (warm and sunny weather).

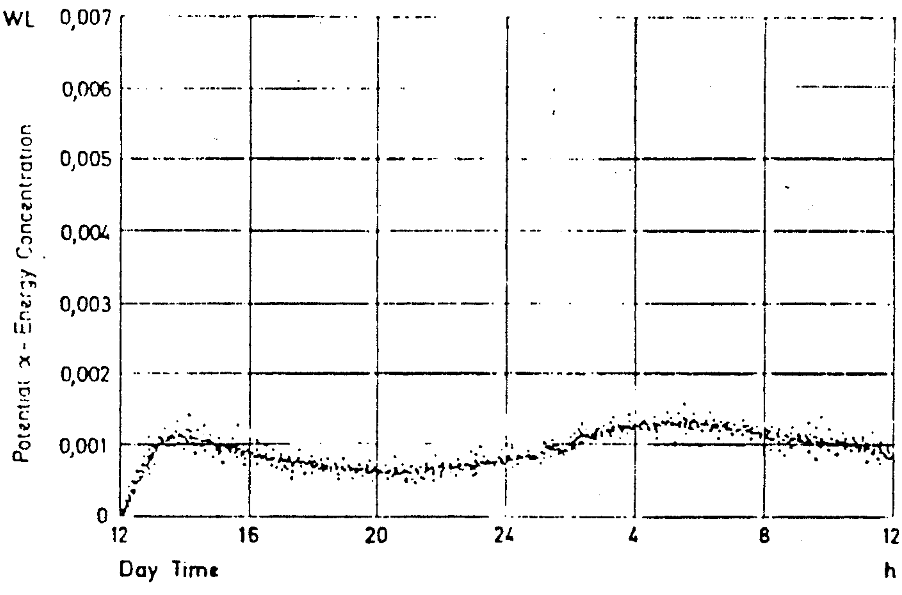

Figure 3. Daily variation of the potential a-energy concentration during 24 h (rainy weather).