Asian Journal of Chemistry Vol. 21, No. 10 (2009), S271-274

Activity Measurements and Dependence of Radon Exhalation Rate on Physical Sample Parameters in Soil Samples

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The measurements of radon concentration and exhalation rates usually consist of measurements of radon contents in an emanation chamber (can) containing a certain sample of material under investigation as a function of radon growth time. The procedure seems to be simple. However, results of radon exhalation rates measurement of the same investigated material strongly depend on physical sample parameters and that is why the results from different laboratories usually differ. In the present paper, we have reported on some factors such as sample mass and sample granulation on the radon exhalation rate measurements. To investigate the effect of above mentioned factors, we have used can technique.

Key Words: Radon, Exhalation rate, Soil, Can.

INTRODUCTION

The measurements of radon concentration and exhalation rates usually consist of measurements of radon contents in an emanation chamber (can) containing a certain sample of material under investigation as a function of radon growth time. The procedure seems to be simple. However, results of radon exhalation rates measurement of the same investigated material strongly depend on physical sample parameters and that is why the results from different laboratories usually differ [1-2]. In the present work, we have also considered some factors such as sample mass and sample granulation.

EXPERIMENTAL METHOD

To investigate the effect of physical sample parameters, radon exhalation rates were measured. For exhalation rate measurements in soil samples, "Can technique" was used [3-5]. In this technique, a known amount (0.1kg) in the present study) of given sample is kept in plastic Cans. LR-115 type II plastic track detector (Batch No. AXE 18007, CAT 5009535, Kotak Pathe France), is fixed on the bottom of the lid of each Can with tape such that sensitive side of the detector

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always faces the specimen. The Can is tightly closed from the top and sealed. Following the exposure for a stipulated period (about 100 days), the LR-115 film detectors are chemically etched using 2.5 NaOH solution. The tracks produced by the alpha particles in the film are observed and counted under an optical microscope by using a calibrated graticule at optimum magnification, say 600X. Large number (about 200) of graticular fields of the detector are scanned to reduce statistical errors.

The growth of radon content (N) in the can with time (t) can be given by a well known

Equation [2,6].

$$N(t) = a\{1 - \exp(-bt)\} \text{ ---------- (1)}$$

where $a = (E_m \cdot M)/b$, for mass exhalation rate and, $a = (E_s \cdot A)/b$, for surface exhalation rate

b- decay constant of radon, E_m- mass exhalation rate, M - the sample mass

E_s - surface exhalation rate, A - the surface area of the sample.

For radon exhalation rate measurements

Calibration factor used here in the measurements was, 0.056 tracks cm^{-2} day^{-1}=1 Bq m^{-3} [7-8]. The mass and surface exhalation rates (E_m and E_s) were calculated using the equations 2 and 3 used by various researchers [9-13].

For mass exhalation rate:

$$E_m = \frac{CV\lambda/M}{T+1/\lambda(e^{-\lambda T}-1)} \quad (Bq\ kg^{-1}\ h^{-1}) \text{ ----------(2)}$$

and for surface exhalation rate:

$$E_s = \frac{CV\lambda/A}{T+1/\lambda(e^{-\lambda T}-1)} \quad (Bq\ m^{-2}\ h^{-1}) \text{ ----------(3)}$$

where C = Integrated radon exposure (Bq m^{-3} h^1), V = Volume of air in can (m^3)

T = Time of exposure (hrs), λ = Decay constant for radon (h^{-1})

A = Area covered by the can or surface area of the sample (m^2)

RESULTS AND DISCUSSION

The calculated values of radon concentration and exhalation rate for soil samples collected from fertile land and barren land in Mathura district (U.P.) are presented in tables 1-4. In table 1, the measured values of radon exhalation rates are presented for samples of the different mass for a give grain size and in tables 2, 3 and 4, the measured values of radon exhalation rates are presented for samples of different grain size obtained by sieving the samples through different sieves and for a given mass of soil samples.

The results given in tables 1, 2, 3 and 4 show that the measured values of radon exhalation rates strongly depend on physical sample parameters. So they should be reported together with the measured values of radon exhalation rates.

Table 1 Effect of mass of the sample on radon exhalation rates (Grain size: ≤ 75 μm)

S. No.	Mass of the sample (kg)	Exhalation rates (GM ± SE*) E_m (mBqkg^{-1}h^{-1})	E_s (mBqm^{-2}h^{-1})
1	0.05	8.7 ± 1.3	185 ± 15
2	0.10	9.4 ± 1.6	192 ± 38
3	0.20	10.3 ± 1.0	205 ± 19
4	0.30	15.4 ± 5.6	306 ± 59
5	0.50	12.4 ± 3.1	212 ± 14
6	1.00	9.1 ± 0.7	168 ± 19

Table 2 Effect of grain size of sample on radon exhalation rates (Sample mass: 0.100 kg)

S. No.	Grain size of the sample (μm)	Exhalation rates (GM ± SE*) E_m (mBqkg^{-1}h^{-1})	E_s (mBqm^{-2}h^{-1})
1	≤75	9.4 ± 1.6	192 ± 38
2	≤ 106 and ≥ 75	6.5 ± 1.2	132 ± 25
3	≤ 150 and ≥ 106	6.8 ± 1.1	135 ± 22
4	≤ 212 and ≥ 150	7.1 ± 1.2	141 ± 24
5	≤ 300 and ≥ 212	8.3 ± 1.0	163 ± 20
6	≤ 500 and ≥ 300	9.4 ± 0.8	184 ± 17

Table 3 Effect of grain size of sample on radon exhalation rates (Sample mass: 0.200 kg)

S. No.	Grain size of the sample (μm)	Exhalation rates (GM ± SE*) E_m (mBqkg^{-1}h^{-1})	E_s (mBqm^{-2}h^{-1})
1	≤75	10.3 ± 1.0	205 ± 19
2	≤ 106 and ≥ 75	10.4 ± 1.8	210 ± 37
3	≤ 150 and ≥ 106	11.0 ± 1.9	218 ± 38
4	≤ 212 and ≥ 150	11.5 ± 2.4	226 ± 46
5	≤ 300 and ≥ 212	12.6 ± 2.6	244 ± 60
6	≤ 500 and ≥ 300	9.5 ± 1.2	189 ± 23

Table 4 Effect of grain size of sample on radon exhalation rates (Sample mass 0.300 kg)

S. No.	Grain size of the sample (μm)	Exhalation rates (GM ± SE*) E_m (mBqkg^{-1}h^{-1})	E_s (mBqm^{-2}h^{-1})
1	≤75	15.4 ± 5.6	306 ± 59
2	≤ 106 and ≥ 75	14.7 ± 3.2	292 ± 64
3	≤ 150 and ≥ 106	15.1 ± 3.3	281 ± 66
4	≤ 212 and ≥ 150	15.0 ± 3.3	297 ± 65
5	≤ 300 and ≥ 212	17.6 ± 4.2	351 ± 53
6	≤ 500 and ≥ 300	15.8 ± 3.2	314 ± 65

* SE (standard error) = $\sigma/\sqrt{N}$, Where σ is SD (Standard Deviation) and N is the no of observations

Conclusions

The results indicate that the measured values of radon exhalation rates strongly depend on physical sample parameters. Our findings are in good agreements of the similar studies carried out in India and abroad [2,6,14]. The findings suggest that the researchers should report the physical sample parameters together with the measured values of radon exhalation rates.

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