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ELECTRET ION CHAMBER METHOD FOR CONTINUOUS MEASUREMENT OF CONCENTRATION OF RADON IN WATER

P. Kotrappa
Rad Elec Inc.
Frederick, MD

S.K. Dua and P.K. Hopke
Chemistry Department, Clarkson University
Potsdam, NY

ABSTRACT

The use of an electret ion chamber for measuring dissolved radon in water sample has been described in a recent publication (Health Physics 6: 397-405; 1993). The current work is a further development of electret ion chamber technology for continuous measurement of dissolved radon in water. A steady concentration of radon in water is generated by bubbling radon gas through a jar of water and maintaining a constant rate of feed and bleed of water. The outgoing water flows into a 4 L cylindrical chamber. Air bubbled at 1 L/min through a 10 cm long sintered stainless steel immersed in this water releases radon from water into the chamber volume. A 1 L electret ion chamber (H-chamber) loaded with an electret is hung in the 4 L chamber. Radon diffuses into the H-chamber through its tyvek (carbon coated) covered openings. The radon concentration in air is measured from the change in electret voltage. The concentration of radon in water is then obtained from the concentration of radon in air and the air and water flow rates. The radon concentration in water is also measured by the standard liquid scintillation counting method. For the concentration range covered (4.7 to 88 Bq/L) there is a good agreement between the two methods.

INTRODUCTION

A passive electret ion chamber method has recently been used for the measurement of radon in water concentrations from the collected water samples (Kotrappa and Jester, 1993). Earlier Dua et al. (1992) had reported an electret ion chamber method for the measurement of time averaged concentration of radon in water. In the latter method, water flowed directly in a 1 L electret ion chamber and radon was released by a supply of air. In this method, there is a possibility of collection of small droplets or charged species on the electret surface resulting in an erroneous drop in the electret surface potential. To overcome this problem water flows into a 4 L Lucite chamber at the center of which the 1 L electret ion chamber is hung. Radon from water is released by bubbling air through a sintered stainless tube.

EXPERIMENTAL SETUP

A steady concentration of radon in water is generated by bubbling radon laden air through water having constant feed and bleed rates. This system is shown schematically in Fig. 1 and described in detail elsewhere (Due et al., 1992).

Fig. 2 presents the system for the measurement of time averaged concentration of radon in water using an electret ion chamber (EIC). Radon water flows into a 4 L Lucite chamber at 10 ml/min. Air bubbled at 1 L/min through a 10 cm long sintered stainless tube releases the radon from water into the chamber volume. A 1 L EIC loaded with an electret is hung at the center of the Lucite chamber. The EIC has 21 holes of 1.27 cm diameter each which are covered with carbon coated tyvek. Radon gas diffuses into the chamber through these openings.

Water from the Lucite chamber drains into a carboy. Its volume is used for calculation of water flow rate.

MEASUREMENT OF CONCENTRATION

The concentration of radon is measured by the continuous EIC (volume 1 L) method, passive (or grab) EIC (volume 200 ml) method and liquid scintillation counting (LSC) method.

In this method radon-laden water flows continuously into a 4 L Lucite chamber and radon concentration in air is measured from the change in the surface potential of the electret in 1 L EIC. The radon concentration in water is then obtained by using equation (1) or (2) as shown below:

From a simple mass balance analysis of the measurement system the radon concentration in the chamber air at any time t is given by

$$R_a = \frac{fR_wQ_w[1 - \exp(-Q_at/V)]}{(VQ_a/V)} \qquad (1)$$

where R_a is the concentration of radon in air, R_w is the concentration of radon in water, Q_w is the water flow rate (L/min), Q_a is the air flow rate (L/min), V is the volume of the Lucite chamber (4L), f is the fraction of radon released from the water into the air and t is the time water is flowing through the chamber. For f assumed to be equal to 1 and $t >> Q_a/V$, equation (1) reduces to

$$R_w = \frac{R_aQ_a}{Q_w} \qquad (2)$$

For the grab EIC method, a water sample collected in a 67 ml glass bottle is opened and shaken in a 3.8 L glass jar loaded with an electret (Kotrappa and Jester, 1993). The change in electret voltage over known exposure time gives the concentration of radon in water.

In the liquid scintillation counting (LSC) method, 10 ml of liquid scintillator (RadScint Extratif from National Diagnostics) is taken in a scintillation vial. From the water samples collected in 67 ml glass bottles, 10 ml is drawn in a syringe and transferred at the bottom of the scintillator. The mixture is shaken well and counted after 3 hours in a precalibrated liquid scintillation spectrometer to obtain concentration of radon in water. Water from the drain of the continuous method is also counted by this LSC method.

RESULTS AND DISCUSSION

Table 1 gives the concentration of radon in water measured by the continuous EIC, grab EIC and LSC methods. There is good agreement between the concentration measured by the continuous EIC method and LSC method. The concentration of radon in the drain water is about 2% suggesting that most of the radon is released from water into air.

The grab EIC method shows lower concentrations. Lower values for the grab method have been previously reported (Kotrappa and Jester, 1993).

The good agreement between the continuous EIC method and the LSC method shows that the continuous EIC method can be used to measure time averaged concentration of radon in water over long periods of time at concentrations levels even lower than that proposed by the US Environmental Protection Agency (300 pCi/L or 11.1 Bq/L). Much higher concentrations over days can be measured by using long term electrets.

REFERENCES

Dua, S.K., Hopke, P.K. and Kotrappa, P. (1992) Continuous measurement of concentration of radon in water using electret method. International Symposium on Radon and Radon Reduction Technology, USEPA Minneapolis, Minnesota, Sept. 22-25.

Kotrappa, P. and Jester, W.A. (1993) Electret ion chamber radon monitors measure dissolved ^{222}Rn in water, Health Physics 64: 397-405.

Table 1. Radon Water Concentration Measurement

	Method			Ratio	
	EIC[a]	EIC[b] (Bq/L)	LSC	EIC[a]/LSC	EIC[b]/LSC
	4.70	4.22	4.44	1.06	0.95
	7.77	7.36	9.21	0.96	0.98
	15.77	13.39	13.84	1.14	0.97
	25.16	22.35	24.20	1.04	0.92
	35.96	29.71	34.71	1.04	0.86
	49.25	42.70	49.25	1.00	0.87
	72.78	68.27	76.70	0.95	0.89
	88.65	74.78	77.63	1.14	0.96
Mean				1.04	0.93
Standard Deviation				0.07	0.05

EIC: Electret Ion Chamber
LSC: Liquid Scintillation Counting
[a] Continuous
[b] Grab

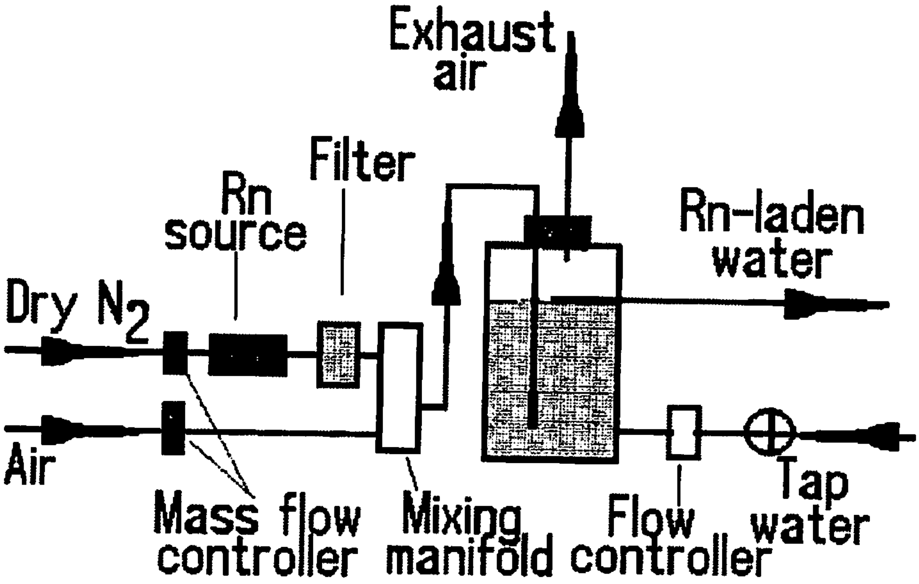

Figure 1. Generation of steady concentration of radon in water

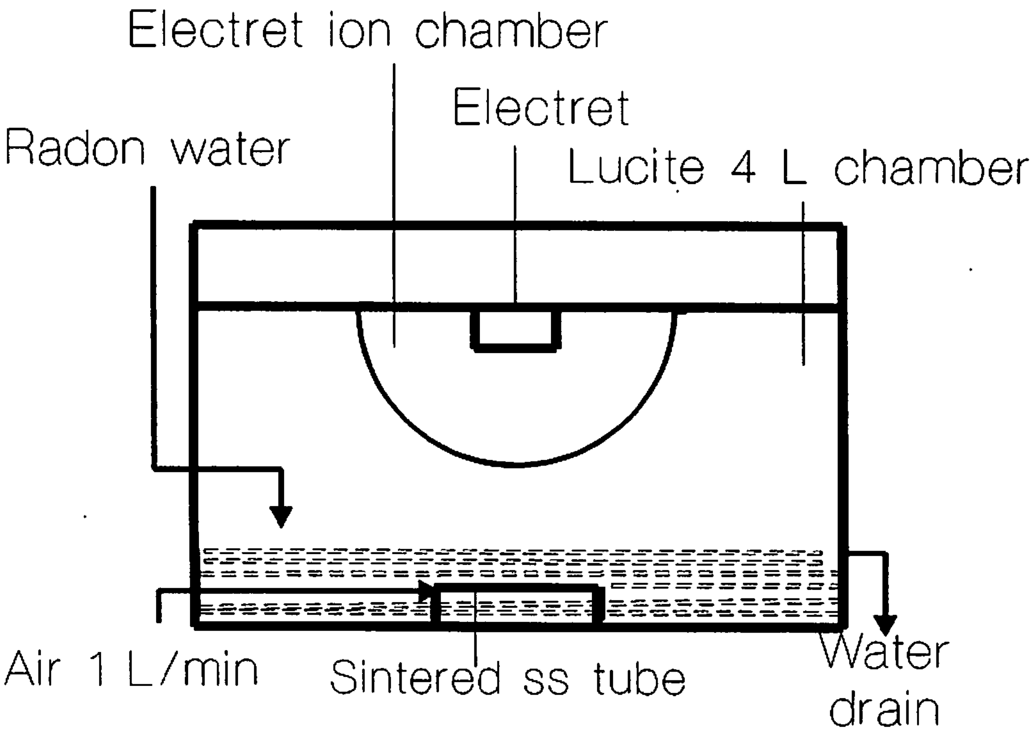

Fig.2. Measurement of conc. of radon in water