ASSESSMENT OF THE E-PERM RADON-IN-WATER MEASUREMENT KIT

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ABSTRACT

Methods currently approved by the Environmental Laboratory Approval Program (ELAP) for the measurement of radon (^{222}Rn) in water in New York State are liquid scintillation counting and de-emanation into alpha scintillation cells. Though not a method approved by ELAP or the U.S. Environmental Protection Agency (EPA), a passive system that uses electret ion chambers (EIC) was evaluated as an alternative for the measurement of radon in water. Water samples from a community water supply containing 870 pCi/L and standards containing 18,500 pCi/L were measured using EIC over 1- to 4-day exposure times. For comparison, identical samples were measured using liquid scintillation counting. The results of duplicate samples were typically within 5% for liquid scintillation counting and within 10% for the EIC. With respect to accuracy, the EIC produced results that were consistently lower by 10-15%, in agreement with other evaluations.

INTRODUCTION

Radon (^{222}Rn) is a gaseous decay product of radium, a naturally occurring radionuclide found in all rocks and soils. In addition to occurrence in the soil underlying a house, radon is also present in groundwater used by the house occupants. Household use of groundwater containing high concentrations of dissolved radon can contribute substantially to the radon level of indoor air. During use of the water for showering, cooking, or washing dishes and clothes, a majority of the radon will be released into the home's air and contribute to indoor concentrations.

Liquid scintillation (LS) counting is a method recommended by the EPA for measurement of radon in water (Whittaker 1989). Preparation of the cocktail for LS counting involves direct injection of the water sample below scintillation fluid in a glass vial. The LS method is inherently easy, rapid, and commonly used. Due to the costs associated with a LS spectrometer, small companies and independent radon-measurement professionals have the need for an inexpensive method to measure the concentration of radon dissolved in a water sample. One such method that is commercially available, and that is evaluated in the present study, is a passive system using an electret ion chamber (RadElec Inc., Frederick, MD). Since past evaluations (Kotrappa 1998) have noted a negative bias when the electret-based method is used, it was necessary to evaluate the technique in anticipation of applications for its use from potential users operating in the state.

EXPERIMENTAL

Water samples that were used for the evaluation of the radon-in-water measurement kit originated from two sources. A community water supply containing 870 pCi/L was sampled 56

times during the study. For collection of the tap water samples, a small funnel was placed under the faucet outlet and water was allowed to overfill slowly. A short, clear tube connected to the outlet of the funnel was filled with water (purged of air) and inserted into the bottom of a collection bottle (64-ml). The water was allowed to overfill the bottle for several seconds before capping with a lid containing a Teflon®-lined septa. At the same time, a transfer syringe was used to extract 10-ml of bubble-free water from beneath the submerged faucet for immediate injection below 10-ml of high-efficiency mineral oil (LS cocktail). After transport to the laboratory and a 4-hr, or longer, ingrowth period, the cocktails were counted once for 50 min each on a liquid-scintillation spectrometer with an absolute efficiency of 64% (3.2 cpm/dpm) for radon and each of its four short-lived α and β emitting decay products. The method blank, with a mean of 2.0 cpm, was subtracted from all LS measurements. Within about an hour of collection, each 64-ml bottle was opened in the laboratory and immediately placed in a 3.8-L glass jar with an electret ion chamber, as directed by the manufacturer (Rad Elec 1998a). The jar containing the electret and water sample was sealed (airtight) and remained undisturbed for 1 to 4 days before determining the electret discharge. The voltage discharge of the electret is used with a formula provided by the manufacturer to determine the radon concentration in the water sample. All LS and ion-chamber measurements were conducted in duplicate.

The second source of radon-laden water used in the evaluation of the electret-based system was developed using identical sealed disks (0.5" filter paper) encapsulated in 36 water-filled glass bottles (44-ml). Each disk, containing a known amount of ^{226}Ra (18,500 pCi/L), was sealed in 2-mil polyethylene and placed in a water-filled bottle that was sealed with a Teflon®-lined septa. Radon ingrowth in the water of forty days or longer was allowed before the two bottles were opened, the encapsulated ^{226}Ra sources were carefully removed, and each bottle was then sealed inside a separate 3.8-L glass jar with an electret ion chamber, as described above. The high concentration of radon in the prepared water samples permitted only 1-day exposures to the electrets to avoid total discharge. LS counting of a 10-ml aliquot of water from six of the vials, and previous studies using the sealed sources (Kitto 2006), confirmed the amount of radon in the vials.

RESULTS AND DISCUSSION

The LS measurements provided a reference for the electret-based method. As shown in Figure 1, activities measured in the 56 tap water samples by LS counting averaged 870 pCi/L. The ratio of the duplicate LS results averaged 0.96. For comparison, the 56 water samples measured for 1-day durations by the electret-based method averaged 740 pCi/L. The ratio of the duplicate electret-based results averaged 0.92. For the tap water samples, the electret-based method produced an average 14% negative bias of this method relative to the LS values, similar to the bias reported previously (Kotrappa 1998) for the method. Similar results were noted for water samples measured for 2-4 day durations.

The vials containing the waterborne radon produced from the encapsulated ^{226}Ra sources were measured in duplicate by LS counting and by using the electret-based system. For the six samples measured by LS counting the radon results averaged 18,600 pCi/L, a value nearly identical to the known amount on the encapsulated filters. For the 30 solutions measured in duplicate using the EIC, the radon concentrations averaged 16,200 pCi/L or 88% of the known

amount. The negative bias for the prepared standards (12%) was somewhat less than that determined for the tap-water samples (14%). The ratios of the duplicate LS measurements averaged 0.95, again indicating proper transfer of the solutions to the LS cocktails, while ratios for the EIC measurements averaged significantly worse (0.87). Radon concentrations in water extracted from the bottom of the 3.8-L jars after the EIC exposure averaged 200 pCi/L, indicating 99% of the radon was released from the waters.

CONCLUSIONS

Standards containing a known amount of radon in water were created and measured by LS counting and an electret-based method. Relative to the LS samples, the tap water radon concentration resulted in a negative bias of 14% for the EIC measurements and a 12% negative bias for the standard solutions. Results of duplicate water samples measured by LS counting and the electret-based method varied by 5% and 10%, respectively. A simple correction by an additional 13% should provide accurate results for the electret-based method.

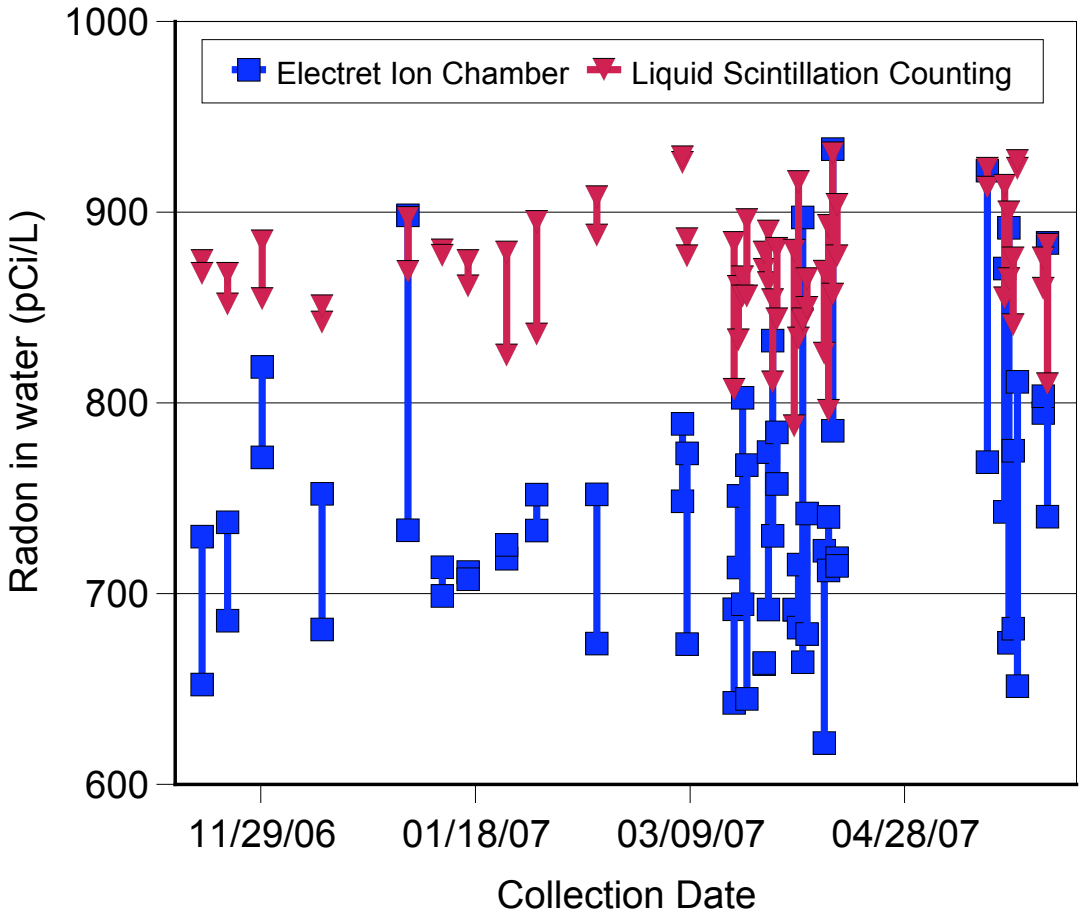

Fig. 1. Radon activities in the duplicate tap water samples measured using EIC and LS counting.

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