CAN CAT LITTER BE A SOURCE OF INDOOR RADON ?

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Abstract

Emanation of radon (^{222}Rn) from several brands of cat (kitty) litter was measured with a continuous radon monitor. Radon emanating from the cat litters, encapsulated in an airtight container, produced equilibrium concentrations below 1.2 pCi/g. The measured radon flux was below 10 pCi/kg-hr for all the cat litters. Although each of the samples emitted a measurable amount of radon, the emanation is too small to raise indoor radon concentrations. The cat litters were measured with gamma-ray spectroscopy to identify and quantify the naturally occurring radionuclides in the samples. Secular equilibrium for the ^{238}U and ^{232}Th radioactive-decay series was evident.

Introduction

Radioisotopes of the three naturally occurring radioactive-decay series, headed by ^{232}Th, ^{235}U, and ^{238}U, are ubiquitous in soils. Although a different isotope of radon is formed in each of the radioactive-decay series, only ^{222}Rn has a sufficiently long half-live (3.8 d) that it often occurs at elevated concentrations in indoor air. The ^{222}Rn isotope, commonly and here referred to as radon, and its decay products have been linked by epidemiological studies to an increased risk of lung cancer, causing approximately 21,000 lung-cancer deaths (Lubin, 1997) annually in the United States (US). A majority of radon entry into a house occurs at the soil-foundation interface, with minor contributions from groundwater use, building materials, and outdoor air.

In the past year, several homeowners and radon mitigators have inquired about radon emanation from cat litter, with the latter group noting increased radon levels in rooms containing a litter box. Given the health implications and the paucity of measurement data, goals of the present study were to quantify the emanation of radon from cat litter and determine the associated gamma-ray activities.

Methodology

Radon

Containers of cat litters that are commonly used in the US were obtained from local retailers (Table 1). All of the cat litters contained granules of clay (e.g, bentonite), and some contained a small portion of silica gel. Radon emanation from the litter samples was determined using the analytical method depicted in Figure 1 in a climate-controlled laboratory containing ~0.3 pCi/L of airborne radon. Samples of the cat litters, with weighs of 143-734 g, were individually sealed inside a 55-L airtight chamber to allow the emanating radon to ingrow to radioactive equilibrium in the enclosed air. Measurements of radon from the cat litters were completed at 1-h intervals using an AB-5 passive radon detector (PRD; Pylon Electronic Development Co. Ltd., Ottawa, Canada). The PRD is an alpha-scintillation counter with a background of 1.1 cpm and a high detection efficiency (1.2 cpm per pCi/L) for radon and its short-lived alpha-emitting progeny. The PRD was placed inside the chamber with each sample, and measurements were conducted up to 194 h. Radon emanated from the cat litter and diffused

Table 1. Samples that were measured.

Cat litter brand
Aldi
American Fare
Arm & Hammer
Arm & Hammer multiple cats
Freshstep
Price Chopper
Scoopaway
Tidycat
Bentonite clay

through the inlet filter of the PRD, to enter the measurement chamber. The equilibrium activity (A_0) was determined by fitting measurement data from the ingrowth of radon in the chamber using the following:

$$A_T = A_0 \left[1 - e^{-\frac{T \ln(2)}{t_{1/2}}} \right] \qquad (1)$$

where A_T is the activity (pCi/L) at time T, and $t_{1/2}$ is the half-life for radon (3.82 d). The PRD

Kitto
Fig. 1

Fig.1. Photograph of the radon detection system used in the analysis of the cat litters.

was calibrated in a certified radon chamber prior to use, and performance was monitored using a manufacturer-supplied ^{226}Ra standard (Model 3150A).

Gamma-ray emitters

Activities of radioisotopes were determined in the cat litters using gamma-ray spectroscopic measurements. The samples were sealed in 0.5-L Marinelli containers and measured for µ1000 min each, using a high-purity germanium detector (HPGe; Canberra Industries Inc., Meriden, CT) in a low-background shield. The absolute detector efficiency was 131%, relative to a 3”x3” NaI(Tl) detector, and the resolution was 1.9 keV at 1333 keV. Spectra, collected for a gamma-ray energy range of 46 to 1765 keV, and were analyzed by the Genie-VMS Spectroscopy System (Canberra Industries Inc.). The detector was shielded by 15 cm of lead, and the counting chamber was purged with nitrogen during the measurements to reduce the concentration of airborne radon-decay products from the room air.

Results and Discussion

Radon

Activity due to ingrowth of radon inside the chamber was measured for each cat-litter sample. The PRD provided confirmation regarding radioactive equilibrium of the samples in the sealed chamber. The solid line drawn through each set of measurement data (Fig. 2) represents the activity expected based on the half-life of radon. In all cases, the observed radon ingrowth

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Fig. 2

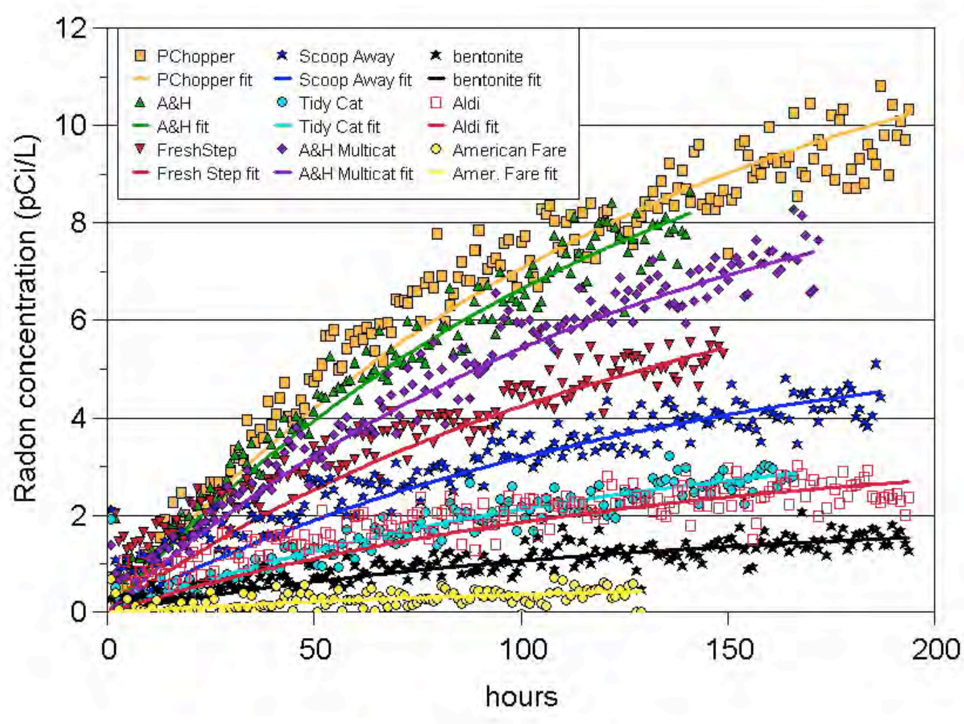

Fig. 2. Radon activities determined in samples of cat litters and bentonite clay. The solid lines represent the expected activities based on the 3.82-d half-life of radon.

coincided well with the expect (theoretical) ingrowth. The net count rates (unequilibrated) from the encapsulated cat litters ranged from 0.5 to 9.1 cpm. The radon concentration in the chamber (A_T) was determined using the relationship:

$$A_T = \frac{(G - B)}{CF} \qquad (2)$$

where G and B are the respective gross and background count rates (cpm), and CF is the calibration factor (1.2 cpm per pCi/L). If allowed to attain equilibrium, the concentrations in the chamber (A_0) would have ranged from 0.7 to 13.3 pCi/L for the cat litters. By applying the chamber volume (55 L), we determined that the total equilibrium activity of radon in the chamber ranged from 38 to 730 pCi. Measurement of the sample masses allowed determination of the equilibrium mass-activity concentration, which varied from 0.3 to 1.2 pCi/g, which is similar to ^{238}U concentrations in soil. Determination of radon flux (F; pCi/kg-d) from the cat litters was determined using

$$F = \frac{A_0 V \lambda}{M} \qquad (3)$$

where V is the volume of the chamber (55 L), λ is the decay constant of radon (0.1814 d^{-1}), and

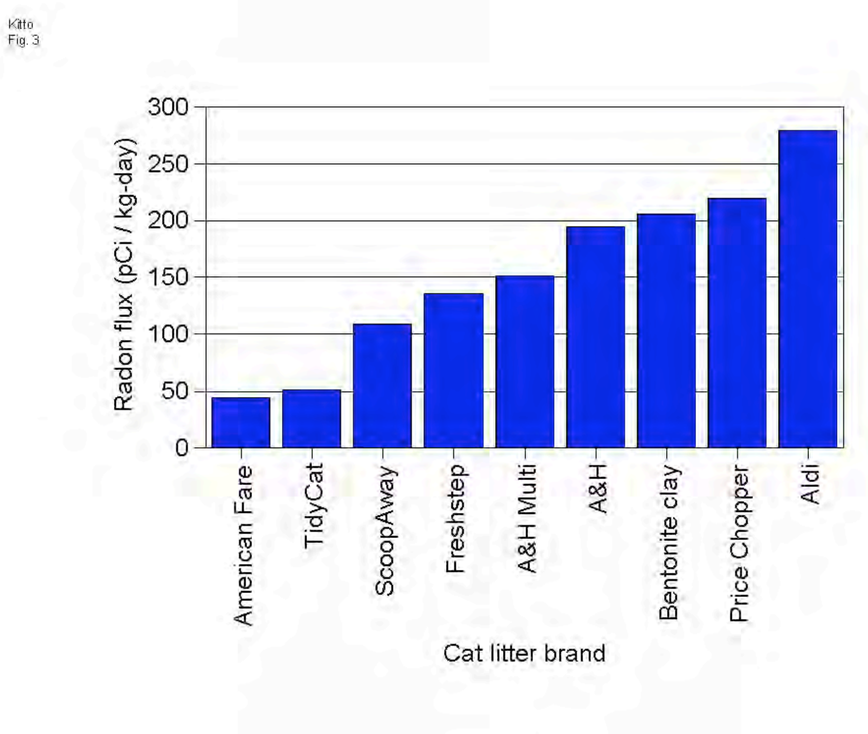

Fig. 3. Radon flux results of the measured samples of cat litter and bentonite clay.

M is the mass of the emanating material (kg). Using the equilibrated radon activities in the chamber, the flux from the cat litters ranged from 49 to 215 pCi/kg-d (Fig. 3). Thus, a litter box.containing 4.5 kg of cat litter will emit approximately 9-40 pCi/hr of radon into a room. Considering that a 20,000 L room filled with outdoor air (0.4 pCi/L) contains roughly 8,000 pCi of radon, the contribution from the cat litter would be undetectable

Gamma-ray emitters

The gamma-ray spectra contained well-defined peaks belonging to the ^{238}U decay series (e.g., ^{214}Pb and ^{214}Bi), ^{232}Th decay series (e.g., ^{228}Ac and ^{212}Pb), ^{235}U, and ^{40}K. During secular equilibrium, the radioisotopes comprising each decay series have identical activities, thus any isotope will provide information on the activities of the entire decay series. Use of a single geometry (0.5-L Marinelli) allowed an intercomparison of the sample results. As shown in Figure 4, the cat litters contain 1.7 to 4.5 pCi/g of ^{238}U and each of its decay products, a range similar to that found in soils. Due to low crustal abundances, isotopes from the ^{235}U decay series

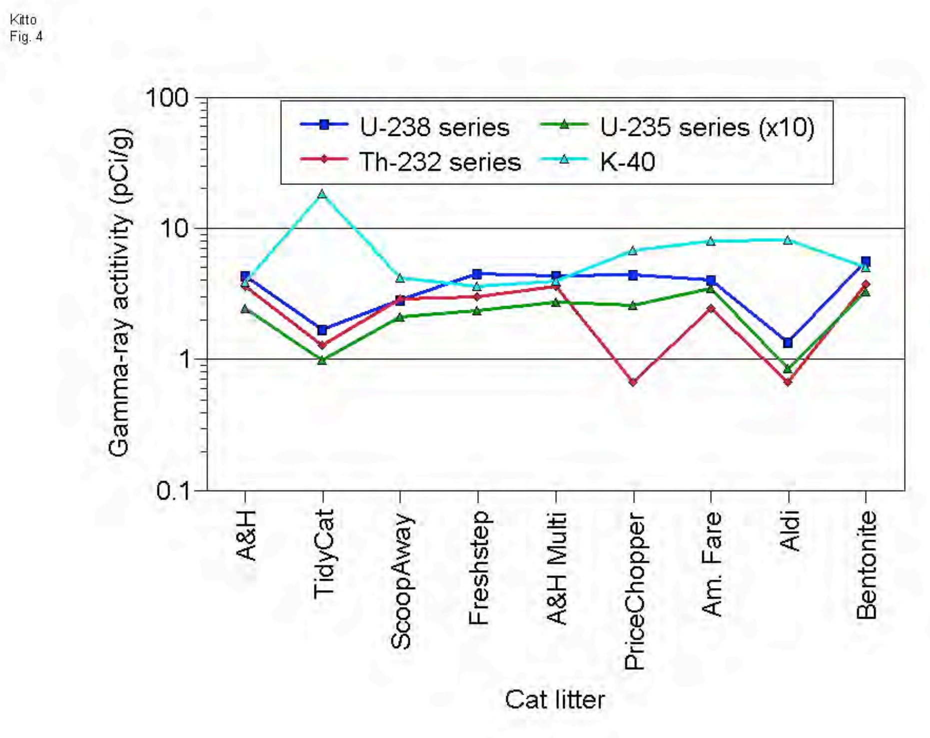

Fig. 4. Gamma-ray activities determined in samples of cat litter and bentonite clay.

are 0.1-0.3 pCi/g in the samples. In nature, the activity of ^{235}U is typically ~5% of the ^{238}U activity, and our measurements confirm the $^{235}U/^{238}U$ ratios in the cat litters were 5-7%.

Concentrations of the gamma-ray emitting isotopes from the ^{232}Th decay series indicate that the cat litters contain 0.7-3.6 pCi/g of ^{232}Th and each of its decay products (Fig. 4). The cat litters contained less activity of isotopes from the ^{232}Th decay series than from the ^{238}U decay series. The isotopes comprising the ^{232}Th decay series have identical concentrations, suggesting radioactive equilibrium.

With one exception, the activities of ^{40}K in the cat litters were similar to concentrations of isotopes from the ^{238}U series and ^{232}Th series. Most of the cat litters contained below 7 pCi/g of ^{40}K, except for one that contained 18.7 pCi/g.

Conclusions

In conclusion, emission of radon from cat litters was determined by a radioanalytical method. The method demonstrated that radon emanates from the cat litters, but the equilibrium activities for the measured samples were below 1.2 pCi/g. Radon flux from the cat litters ranged from 49 to 215 pCi/kg-d. Gamma-ray activities for ^{40}K and radioisotopes from the ^{238}U- and ^{232}Th-decay series were determined in samples of cat litters used in the US. The majority of activity concentrations were similar to values found in soil. Results indicate that none of the cat litters contain sufficient radioisotope concentrations to confer a health issue.

References

Lubin JH, Boice Jr. JD. Lung cancer risk from residential radon: meta-analysis of eight epidemiologic studies. J. Natl. Cancer Inst. 89:49-57; 1997.