Radon: How to Assess the Risks and Protect Your Home

Jason P. de Koff and Brad D. Lee, Purdue University Department of Agronomy;
Paul L. Ziemer, Purdue School of Health Sciences

Radon is an odorless, invisible, radioactive gas that is produced by the radioactive decay of its "parent" element, radium, which is naturally present in some soils and rocks. Radon can accumulate in the home and has been found to cause certain types of cancer.

This publication examines the effects of radon exposure, describes common sources of radon in the home, and discusses radon testing and mitigation.

Effects of Radon Exposure

Just as it is produced by radioactive decay, radon disappears by radioactive decay. In this process, it releases radiation in the form of alpha particles and transforms into a different element. The relative time this decay takes is based on radon's half-life, which is 3.8 days. Half-life is the time it takes half of the original amount of radon to decay. For example, if you started with 100 radon atoms, there would be 50 atoms remaining after 3.8 days, 25 atoms after another 3.8 days, and so on. Although radon has a short half-life, it is constantly replenished in the environment by the decay of the long-lived radium also present in some soils and rocks. Indoor levels of radon vary depending on the rate that radon is leaking in from outside (Brown et al., 2000).

Inhalation is the most likely source of radon exposure in the home. Since the late 1960s this type of exposure has been known to cause lung cancer. Ingesting radon, usually from drinking water containing radon, is less likely (but still possible) and has been linked to stomach cancer and other cancers of the digestive tract (U.S. EPA, 2005a).

The majority of the radiation involved is actually emitted from the radon decay products which alter or harm DNA in human tissues and lead to the development of cancer (Brown et al., 2000). Radon decay products are metallic elements that cling to small particles, allowing them to be inhaled and deposited in the lungs.

Important health statistics related to home radon levels include:

- Radon causes an estimated 21,000 deaths each year from lung cancer (U.S. EPA, 2003) (Figure 1).
- Radon is second only to medical X-rays as the most significant source of radiation exposure for most people (Figure 2).
- Radon is the second leading cause of lung cancer after smoking according to the U.S. Surgeon General (2005). Those who smoke and have homes with high radon levels are at even greater risk.

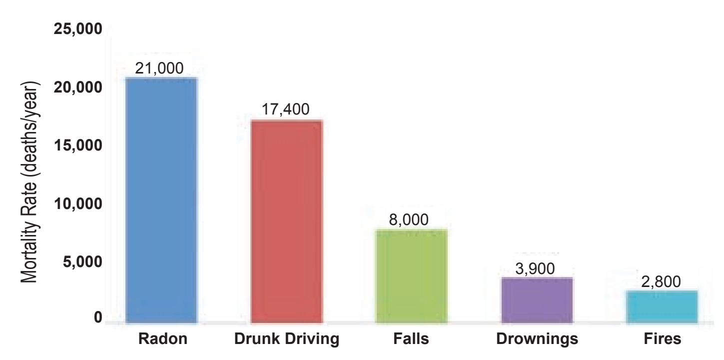

Figure 1. Common Mortality Rates
This graph shows the annual mortality rates from radon exposure and other sources (adapted from U.S. EPA, 2005a).

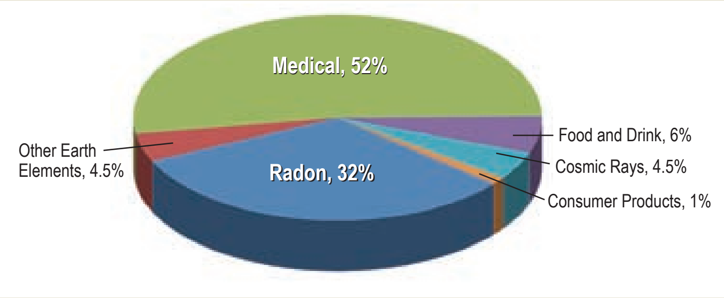

Figure 2. Sources of Individual Radiation Exposure
This graph shows the most common sources of radiation exposure for the average individual according to National Council on Radiation Protection and Measurements estimates (adapted from NCRP, 1987; Mettler 2007).

Factors Affecting Radon Levels

Radon levels in a home can vary over time and in different locations depending on the area's soil type and geology, the home's building materials and foundation, weather and season, and level of radon in the household water supply. Below are some basic facts about the factors that affect home radon levels.

Soil and Geology

Soil type and geology have the greatest effect on radon levels in the home, and is typically the largest source of radon (Figure 3). A major factor affecting radon flow is how porous the soil is beneath the home. Soils and rock that are more porous allow more radon to flow into a home (Table 1). Glacial till soils derived from sandstones, limestones, and black shales common in the Midwest create a high radon potential.

Building Materials and Foundation

Some concretes and sheetrocks may contain materials with high levels of uranium that can continuously decay to radon (Brown et al., 2000). Some concrete foundations are more porous than others or may contain cracks. These factors allow radon from the soil and rock beneath the home to flow into the home at a faster rate.

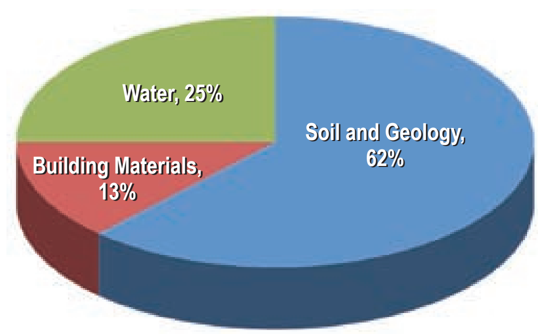

Figure 3. Sources of Radon in the Home
This graph shows the average proportions of the leading sources of radon in the home in the United States (adapted from Brill et al., 1994).

Soil types allowing greater movement of radon into the home
Loose, gravelly soil, and sandy soils found in sedimentary and glacial deposits
Well-drained soils on sloped land
Soils that dry and form shrinkage cracks
Thin soil over faulted, fractured, or cavernous rock systems

Table 1. Soils Contributing to HIgh Radon Movement
This table shows soil types that allow for greater movement of radon into the home (adapted from Brown et al., 2000).

Weather and Season

The weather and season also affect the amount of radon present in the home. Radon is not very water soluble, so rainfall entering the soil will temporarily block the pores in the soil and reduce the flow of radon into the home. In the winter, radon levels can increase. This is because heating systems can create a slight buildup of negative pressure between the inside and outside, causing more air (and more radon) to flow inside from beneath the home (Appleton, 2005).

Household Water Supply

Household water supplies also can be a source of radon. Water that comes from underground sources (such as aquifers or wells) is more likely to contain higher radon levels than water that comes from surface sources (such as lakes or reservoirs). This is because radon from groundwater does not have a chance to diffuse into the atmosphere like surface water does (U.S. EPA, 2005a). Once in the home, water with elevated radon levels can cause radon to diffuse into the indoor atmosphere and increase overall radon levels (Appleton, 2005).

Testing for Radon

The EPA and Surgeon General suggest radon testing below the third floor for all structures. The maximum radiation level allowed by the EPA for any building is 4 pCi/L (picocuries of radon per liter of air). The average outdoor level is about 0.4 pCi/L and the average indoor level is around 1.3 pCi/L. It is estimated, however, that 1 in every 15 U.S. homes has radon levels greater than 4 pCi/L (U.S. EPA, 2005a). If the air in your home is above this level, mitigation efforts (see below) are strongly advised.

The EPA developed a map that shows areas at the greatest risk from high radon levels based on a number of factors, including average indoor measurements, geology, aerial radioactivity, soil permeability, and typical household foundation types (Figure 4). These maps are only estimates, however, and the EPA recommends testing if:

- It has been more than two years since the last test
- You are buying a home
- Your home or yard was recently renovated

At least 18 million homes were tested for radon from the mid-1980s through 2003. Of those, 800,000 with elevated levels have installed mitigation systems (Gregory and Jalbert, 2004). According to data from the Indiana State Department of Health, certified radon professionals performed more than 45,000 radon tests around the state between 1994 and 2004. In those tests, one in three found elevated radon levels (levels greater than or equal to 4 pCi/L).

Homeowners can test for radon by purchasing a test kit from a hardware or retail store, or hire a certified radon professional. There are short-term and long-term radon tests available.

Short-term testing can take two to 90 days to complete and are good for quick results. If this test is going to be used, however, it should be followed by a second short-term test after the first one is completed (U.S. EPA, 2005a).

Long-term testing usually takes longer than 90 days. Such tests can provide the most accurate results since, as mentioned earlier, radon levels in a home can vary over time.

Radon Mitigation Methods

The two main ways to reduce radon concentrations are to prevent radon from entering the home in the first place and to dilute the indoor air with ventilation from outside. To lower radon levels, homeowners can use passive or active mitigation methods (Brown et al., 2000).

Passive Mitigation Methods

Passive mitigation methods are the least expensive and are typically good for homes that have radon levels only slightly above the 4 pCi/L limit (Henschel, 1993). Such methods include sealing foundation openings and around areas where pipes enter the home — such measures can reduce radon levels by as much as 15 percent (Nielson et al., 1996). Other methods include applying coatings or membranes on walls to reduce permeability and installing a passive soil ventilation system. In these systems vents can be installed around a crawlspace to allow outside air to mix with air from the soil beneath the flooring.

Active Mitigation Methods

Active mitigation methods are typically more expensive than passive methods — anywhere between $500 and $2,500 to install, plus operating costs. (Appleton, 2005). However, such methods are important for structures with high radon levels (more than two or three times the 4 pCi/L limit), or if passive mitigation methods do not work. Active systems typically involve installing mechanical and electrical devices to reverse air flow and ventilate soil beneath the foundation. They are set up either to draw outdoor air toward the foundation or blow air in the soil away from the foundation (Henschel, 1993).

Precautions for Building Homes

When building a new home, there are also a number of measures that can be taken that cost less than installing a mitigation system in an existing home — $350-$500 during the construction of a new home vs. $500-$2,500 for installing a system in an existing home (Appleton, 2005). Such measures are especially advised if the new home is located in Zone 1 (red areas) on the EPA radon zone map (Figure 4).

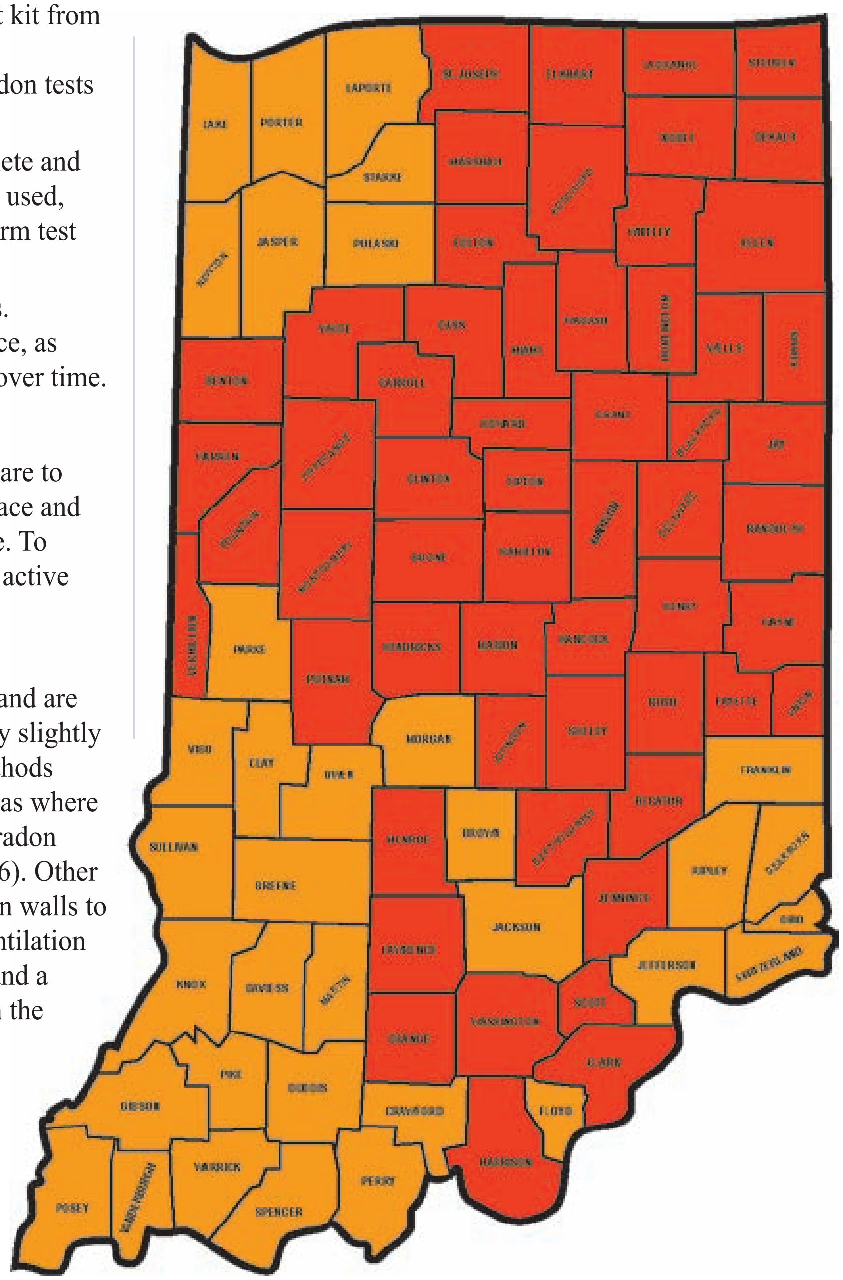

Figure 4. EPA Map of Radon Zones

This EPA map estimates the relative levels of radon that may be present in Indiana homes. Homes built in red areas (Zone 1) are predicted to have radon levels greater than the maximum radiation levels the EPA sets, 4 pCi/L. Homes in orange areas (Zone 2) are predicted to have radon levels between 2 and 4 pCi/L.

Builders can place plastic membranes beneath the foundation, use a more dense concrete mixture for the foundation, and use solid masonry blocks instead of hollow blocks for the foundation walls that can prevent air containing radon from penetrating the home (Brown et al., 2000).

Further Information

In Indiana

Indiana Radon hotline
(800) 272-9723

In the United States

National Safety Council National Radon Helpline
(800) 55RADON (557-2366)
www.nsc.org/issues/radon

You can also order a radon test kit by calling the number above or visiting www.nsc.org/issues/radon/radonkitcoupons.pdf

Environmental Protection Agency
www.epa.gov/radon

EPA Safe Drinking Water Hotline
(800) 426-4791

www.epa.gov/safewater/radon.html

Find a Qualified Radon Contractor

Indiana State Department of Health Indiana Certified Radon Testers and Mitigators List
www.in.gov/isdh/regsvcs/radhealth/pdfs/radon_testers_mitigators_list.pdf

EPA radon professionals page
www.epa.gov/radon/proficiency.html

Other Home & Environment Publications

Visit the Home & Environment Web site for science-based information about homes and the home environment: www.ces.purdue.edu/HENV/index.htm.

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U.S. EPA. 2005a. A citizen's guide to radon: the guide to protecting yourself and your family from radon. EPA 402-K-02-006, Washington, D.C.

U.S. EPA. 2005b. Home buyer's and seller's guide to radon. EPA 402-K-05-005, Washington, D.C.

U.S. Surgeon General. Press release, January 13, 2005. "Surgeon General releases national health advisory on radon." United States Surgeon General, Department of Health and Human Services, Washington, D.C.

Authors:

Jason P. de Koff, Graduate Research Assistant, Department of Agronomy, Purdue University

Brad Lee, Assistant Professor and Soil and Land Use Extension Specialist, Department of Agronomy, Purdue University

Paul L. Ziemer, Professor Emeritus and Former Head, School of Health Sciences, Purdue University

Visit the Home & Environment Web site for science-based information about homes and the home environment: http://www.ces.purdue.edu/HENV/index.htm.

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