PENNSTATE

College of Agricultural Sciences Cooperative Extension

Agricultural and Biological Engineering

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Reducing Radon in Drinking Water

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Since the late 1980s, radon has become a highly publicized health threat. This naturally occurring radioactive gas has seeped out of the earth's crust and into the basements of thousands of homes across the nation. Until recently, radon concerns have focused primarily on airborne radon; radon in drinking water was not considered a problem. Now water tests reveal its presence and many homeowners are asking "How can I reduce radon in my water supply?" This fact sheet provides information about radon in drinking water and describes reduction methods.

Health Effects

Projected or estimated risks of developing lung cancer from radon contaminated water...

1,000 pCi/L...........3-13 in 10,000
10,000 pCi/L...........3-13 in 1,000
100,000 pCi/L............3-12 in 100

Source: EPA, Removal of Radon from Household Water, September 1987

Facts About Radon

Source

Radon is a naturally occurring radioactive gas formed from decaying uranium or radium deposits. It escapes from the earth's crust through cracks and crevices in bedrock and either dissolves in groundwater or seeps through foundation cracks into basements and homes. Radon can also be emitted from the soil. Once produced, radon begins to move toward the surface and decays to a series of elements. These radon decay products or "daughters" move less freely in the air than radon. As a result, they eventually attach to dust particles in the atmosphere. Any radon not filtered out by the nose, thus becomes a health problem.

Health Effects

Recent studies of uranium and lava rock miners have shown that inhalation of radon daughters increases the chances of lung cancer. The extent of these effects and the risk estimates involved are difficult to determine. Still, the Environmental Protection Agency (EPA) has made some estimates as shown in the "Health Effects" data. These estimates are for radon released from water and then inhaled. Generally, ingested waterborne radon is not a major cause for concern. Although scientists have linked cases of stomach cancer to radon daughters present in the digestive tract, the evidence remains inconclusive.

Waterborne Radon

Waterborne radon usually originates in deep wells that tap radon-contaminated groundwater, although community water supplies with surface reservoirs may also have a problem with radon. Typically, waterborne radon levels are much lower than atmospheric levels. Still, even small amounts of the gas increase household air levels during showering, laundering, and dishwashing. EPA estimates that 2-5 percent of airborne radon comes from household water. They further estimate that even these small percentages increase the incidence of cancer. If radon is discovered in water, it is likely that radon is entering the house through the basement as well.

Currently, the EPA has not set official standards for either airborne or waterborne radon. EPA suggests that an airborne level of 4 pCi/L is a point at which remedial action should be taken. Recognize that for every 10,000 pCi/L in water about 1 pCi/L will be released in the air. EPA's proposed limit for radon in water is 300 pCi/l. One study estimates that 60% of Pennsylvania's well water supplies including community supplies will not meet this standard.

Detection and Testing

Since radon is an invisible, odorless gas, you may be wondering how it can be detected in your water supply. Radon and its daughters are radioactive—continually decaying and emitting radioactive particles called alpha and beta rays. Therefore, testing for radon in water requires special sampling and laboratory analysis techniques that measure its presence before it escapes from the sample.

Direct water sampling is by far the most accurate testing method. Radon test kits are available from private testing laboratories*. Test kits include two sample vials containing fluid and a 12 cc plastic syringe. An instruction sheet is also included to insure proper sampling techniques. For example, the aerator must be removed from the tap; water should be run for three minutes before sampling; and the sample must be injected beneath the fluid in the small vial.

Treatment

Radon water treatment should remove radon before it becomes airborne. Remember, the presence of waterborne radon indicates that radon is probably entering the house through the basement as well. Therefore, treating the water without reducing other sources of incoming airborne radon probably will not eliminate the radon threat. The next section discusses two means of reducing waterborne radon only.

Point-of-Entry Treatment

One method for removing radon from water is a granular activated carbon (GAC) unit. Although these units come in a variety of models, types and sizes, they all follow the same principle for removal. Figure 1 shows a typical GAC unit. For radon removal, GACs are constructed of a fiberglass tank containing granular activated carbon—a fine material that traps and holds the radon. Because of the carbon's fine particle size, it easily clogs with sediments or other contaminants present in the water. Some GAC units come with a special backwashing feature for removing sediment. These eventually reduce the effectiveness of the carbon to remove radon. Elimination of the sediment source or a sediment filter placed ahead of the GAC tank is the best protection against clogging.

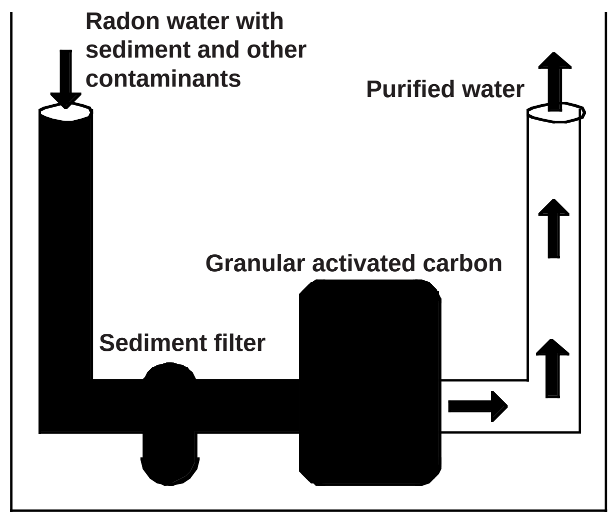

Figure 1: Treatment by activated carbon.

At what maximum radon level a GAC unit effectively operates is uncertain. Some estimates show that it should not be used if waterborne radon levels exceed 30,000 pCi/l. Other experts say 5,000 pCi/l. The best way to decide is to have your water tested and then investigate GAC filters that have high removal efficiency rates at the level found in your water. If you do decide to purchase a unit, select a filter size that matches water use and conditions. According to EPA, a three-cubit-foot unit can handle as much as 250 gallons of water per day and effectively reduce radon levels. Typical water use in the home ranges from 50 to 100 gallons per person

*Currently there are no certified labs for testing radon in Pennsylvania. A list of labs that perform the radon test can be obtained from the Bureau of Radiation Protection (DEP). Call 800-237-2366 or access the list at http://wqext.psu.edu per day. Size and special features both affect costs, which can start at $700 depending on the unit. They can be purchased commercially through water treatment dealers. Be sure to investigate thoroughly the company and their products before purchasing any unit. GAC filters will remove radon indefinitely providing that sediments or organic pollutants have not clogged the filter.

A major drawback to the use of GAC filters is that if radon is present the filter becomes radioactive as it picks up the gas. Lead-210 (a radon daughter) builds up on the carbon filter and then gives off its harmful radioactive rays as it continues to decay. IT IS EXTREMELY IMPORTANT TO PLACE THE UNIT OUTSIDE THE HOME OR IN AN ISOLATED PART OF THE BASEMENT. A SHIELD MAY BE REQUIRED IF RADON LEVELS ARE HIGH (GREATER THAN 30,000 PCI/L).

GAC filters may produce a radiation problem when the device is used to remove other contaminants. For example, a homeowner installs a GAC unit to remove a pesticide without testing the water for radon. The GAC unit sits under the sink harmlessly removing the problem contaminant. Right? Wrong. Unfortunately, what the homeowner doesn't know is that the water supply has very high radon levels. So while the GAC traps the pesticide it also traps radon thus producing a radioactive filter and a radiation hazard.

Proper maintenance and handling of the GAC unit can minimize exposure risks. Redevelopment of the well intake or a sediment filter is vital to protecting the fine carbon from fouling and clogging; protected filters won't need to be changed as often. Also, you should periodically retest the water to insure that radon is still being removed. IF FOR ANY REASON, THE UNIT OR FILTER MUST BE REMOVED OR REPLACED, BE SURE TO CONTACT THE DEPARTMENT OF ENVIRONMENTAL RESOURCES* FOR SAFE DISPOSAL OF THE SPENT FILTER.

Home Aeration Units

EPA has listed aeration as the best available technology for removing radon from water. Home aeration exposes the water to enough air so that radon can escape to the air before the water reaches your taps. With new technological advancements in home aeration, these units can have radon removal efficiencies of up to 99.9%. They are also ideal for high waterborne radon levels. However, you should be aware that to date, neither the National Sanitation Foundation or the Water Quality Association has tested these units. In addition, home aeration units are expensive usually starting at around $3000. This cost doesn't include installation or maintenance costs. The following information describes three aeration units currently available for residential use.

A spray aeration unit as shown in Figure 2, sprays radon contaminated water into the tank using a spray nozzle. The increased surface area of the sprayed water droplets causes the radon to volatilize while the air blower carries the radon contaminated air to a vent outside the home. About 50% of the radon will be removed in the initial spraying. The water must be sprayed several times to increase removal efficiencies. To keep a supply of treated water, at least a 100-gallon holding tank must be used.

The second type of aeration unit is the packed column. Water moves through a thin film of inert packing material in a column. The air blower forces radon contaminated air back through the column to an outdoor vent. If the column is high enough, removal efficiencies can be between 90-95%. For the 6-foot column shown in Figure 3, the removal efficiency is around 95%. Packed columns become impractical if radon exceeds 20,000 pCi/l.

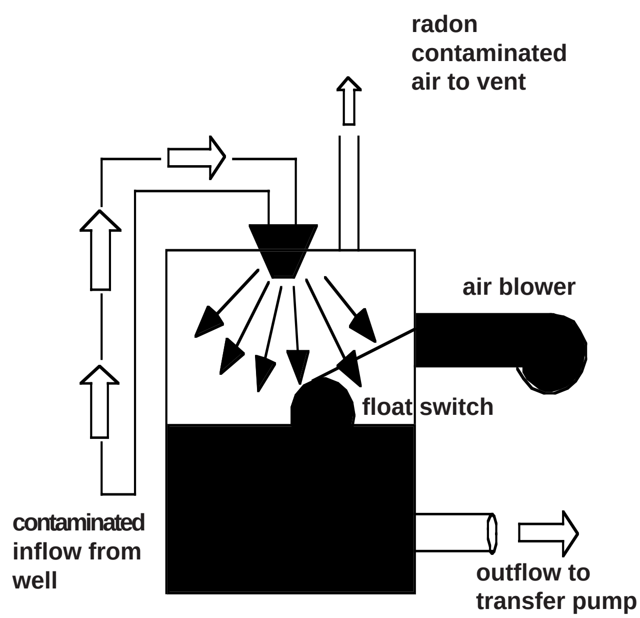

Figure 2: Radon removal with a home spray aeration system.

* Department of Environmental Protection
Bureau of Radiation Protection, P.O. Box 2063
Harrisburg, PA 17120. 1-800-23R-ADON

A final aeration system uses a shallow tray to contact air and water. Water is sprayed into the tray, and then flows over the tray as air is sprayed up through tiny holes in the tray bottom. The system removes more than 99.9% of the radon and vents it outside the home. The treated water collects in the tank bottom and is pumped to the water pressure tank. Advantages of this type of aeration include: low pressure air blower, no fouling problems in tray holes, and the small unit size. However, this system uses 100 cubic feet per minute of air compared to the others. This can depressurize the basement.

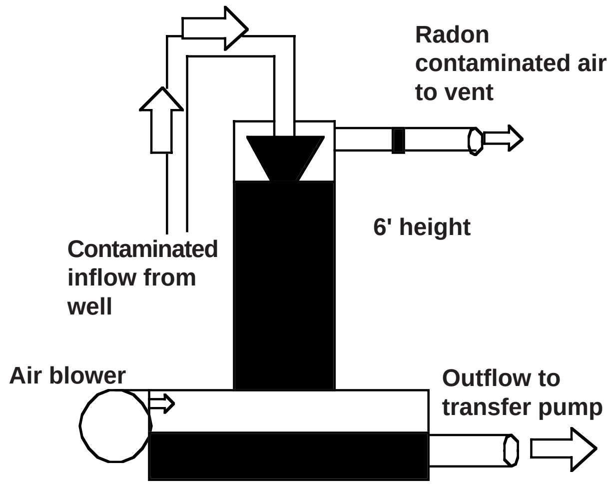

Figure 3: Radon removal with a packed column.

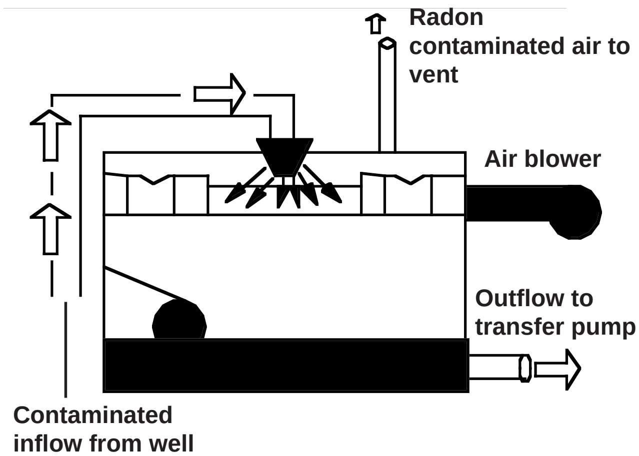

Figure 4: Radon removal by horizontally extended shallow aeration.

Additional Resources

For further water quality information and resources:

Please access:
Website: http://wqext.psu.edu
Email: mxh16@psu.edu
Fax: (814) 863-1031
Phone: (814) 865-7685

For more information about other Outreach Publications and Resources from the Department of Agricultural and Biological Engineering:

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PSU rev. 8/01