Information Pamphlet 3

Radon and You: Promoting Public Awareness of Radon in Montana's Air and Ground Water

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Montana Bureau of Mines and Geology
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Acknowledgements

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More comprehensive information may be obtained from the Montana Department of Environmental Quality web page (www.deq.mt.gov).

Kathleen J. Miller
Michael A. Coffey

Radon and You:
Promoting Public Awareness of Radon
in Montana's Air and Ground Water

What Is Radon?

Radon is an invisible, naturally occurring, colorless, odorless, radioactive gas that is a daughter product of the decay of uranium. The U.S. Environmental Protection Agency (EPA 1992) estimated that between 7,000 and 30,000 lung cancer deaths in the United States each year are caused by breathing radon gas. In fact, radon is believed to be second only to smoking as the major cause of lung cancer in the United States. Although the EPA and the Surgeon General warn that smokers have a higher risk of developing lung cancer from radon exposure than non-smokers, the radon levels in all homes can be reduced.

Very low concentrations of uranium occur in many rocks and soils. Some rock types, such as granite, contain more uranium than others, and thus produce more radon. However, most soils in Montana generate at least some radon. The half-life of radon is 3.8 days. Radon concentrations are measured in units of radioactivity called picoCuries. The national average background level of radon in outdoor air is between 0.2 and 0.7 picoCuries per liter (pCi/L). For indoor air, the national average is 1.3 pCi/L, but in Montana the average is 5.9 pCi/L.

Radon is listed as the second leading cause of lung cancer in the United States.

Radon gas can move from the surrounding soils and accumulate in enclosed areas such as homes and underground mines, when the atmospheric pressure inside the structure is lower than the surrounding pressure. Indoor air that is warmer than outdoor air rises in homes and pulls cooler air in from the outside. Blowing wind and heavy rainfall can also increase the movement of radon into a house.

So far, most efforts toward radon education have been focused on radon's entry into homes from the soil through cracks in building floors and foundations. Yet in areas where ground water contains high levels of radon, water can also contribute radon to indoor air through common household activities such as showering, bathing, clothes washing, dish washing, and cooking. In general, surface water, such as rivers and lakes, contains lower levels of radon than ground water.

What Can Radon Do to People?

Radon was identified as a health problem when scientists found that underground uranium miners who were exposed to it died of lung cancer at rates far above what was expected. Most of what is known about radon's cancer-causing potential comes from the study of these miners.

Radon is listed as the second leading cause of lung cancer in the United States. Primarily, there are two ways in which people come in contact with radon: inhalation and ingestion. Exposure from inhalation is caused by the radon decay products rather than the radon. Radon and its radioactive decay products can be breathed into the lungs where they irradiate the lung tissue, and this can cause lung cancer. The risk of developing lung cancer from radon exposure is related to the concentration of radon in the air, but the risk increases by up to ten times for smokers. If radon levels in all homes were reduced to an annual yearly average 4 pCi/L of air, it is possible that around one-third of the radon-related cancer deaths might be prevented.

It is known that there is a relationship between radon concentrations in indoor air and the incidence of lung cancer. There is some risk linked to the ingestion of radon directly from the drinking water as well as from the inhalation of radon gas released from water to the indoor air. Turbulent or heated water (flowing in wash basins, showers, washing machines, flush toilets, etc.) is a source of elevated radon levels in the home, as these activities liberate dissolved radon into the home air. The

A Glossary of Chemistry and Health Terms

A **picoCurie** is one-trillionth of a Curie, or about equal to the decay of two radon atoms per minute in a liter of air.

The **half-life** of a radioactive element is the time required for half of a given number of atoms to disintegrate, or decay.

The risk due to **inhalation** is from breathing radon gas.

The risk from **ingestion** is due to eating or drinking water containing radon gas.

Radon daughters are short-lived new elements, products of the radioactive decay of radon, also known as radon progeny.

Mitigation means “to fix a problem” or to cause to become less of a problem.

Dose is the quantity of radiation absorbed by an individual.

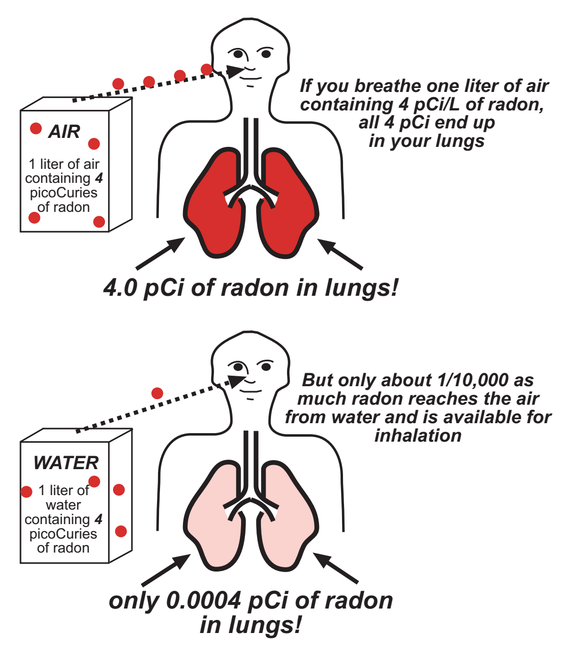
To **irradiate** means to expose tissues to radiation.

Adsorption is where radon molecules are retained on the surface of the charcoal in a charcoal canister.

Acute dose means a person received a radiation dose over a short period of time.

Chronic dose means a person received a radiation dose over a long period of time.

Radioactive decay is the natural breakdown of uranium that produces in radon.

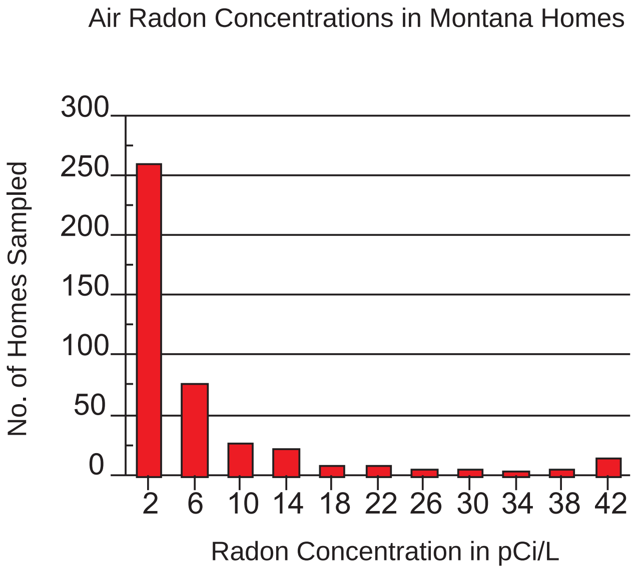


Air has a lower safe level (4 pCi/L) than water (300-3,000 pCi/L) because all of the radon in air can enter the lungs, but only a small portion of the radon in water is introduced into the lungs.

amount released depends on the radon content of the water (which varies widely between regions) and the amount used (70 to 250 gallons in a typical household per day).

What are Safe Levels of Radon in Air and Water?

The U.S. Environmental Protection Agency (EPA) has set 4 picoCuries/Liter (pCi/L) as a recommended annual average level for a lifetime exposure to radon in indoor air. The EPA is currently proposing standards, or maximum contaminant levels (MCLs), for radon in public drinking water supplies. Subject to the results of a study by the National Academy of Sciences to be published in September 1998, two MCLs may be proposed; a low MCL at 300 pCi/L and an alternative MCL at 3,000 pCi/L. These standards address health risks from both inhalation and ingestion of radon.



Radon concentrations in Montana homes based on samples collected in the winter of 1992.

Where Is Radon Found in Montana?

Radon can be found throughout Montana. Regions of the state where concentrations are higher depends on the geology of the area. Because of limited data only general interpretations of the correlation of geology to radon in air and ground water are possible.

The following descriptions should not be used as a substitute for indoor radon testing; nor should they be used to estimate or predict the indoor radon concentrations of individual homes or building sites.

The purpose of this section is to provide general information to Montana citizens and to assist state and local governments and organizations to target radon program activities and resources.

Radon Geology in Montana

Since the late 1970s, the link between geology and radon in indoor air has been documented. The U.S. Geological Survey used not only the indoor air data gathered by the Montana Bureau of Mines and Geology (MBMG), but also aerial radioactivity data acquired from airplanes, geologic data, soil

A Glossary of Geologic Terms

Geology is a term that means *the study of the Earth.*

Hydrogeology is the study of underground water, or, ground water.

An **aquifer** is a permeable material through which ground water moves. An aquifer produces enough water to supply a well.

The **Quaternary** geologic period covers the last 2 million years. Continental glaciers occurred during the Quaternary period, as did the appearance of the first human beings.

The **Tertiary** period, lasted from about 2 million years ago to about 65 million years ago. As a point of interest, it was during the Tertiary period that the Yellowstone volcanoes began and horses first appeared.

In the **Cretaceous** period, from about 65 million to about 135 million years ago, the Rocky Mountains rose and the dinosaurs became extinct.

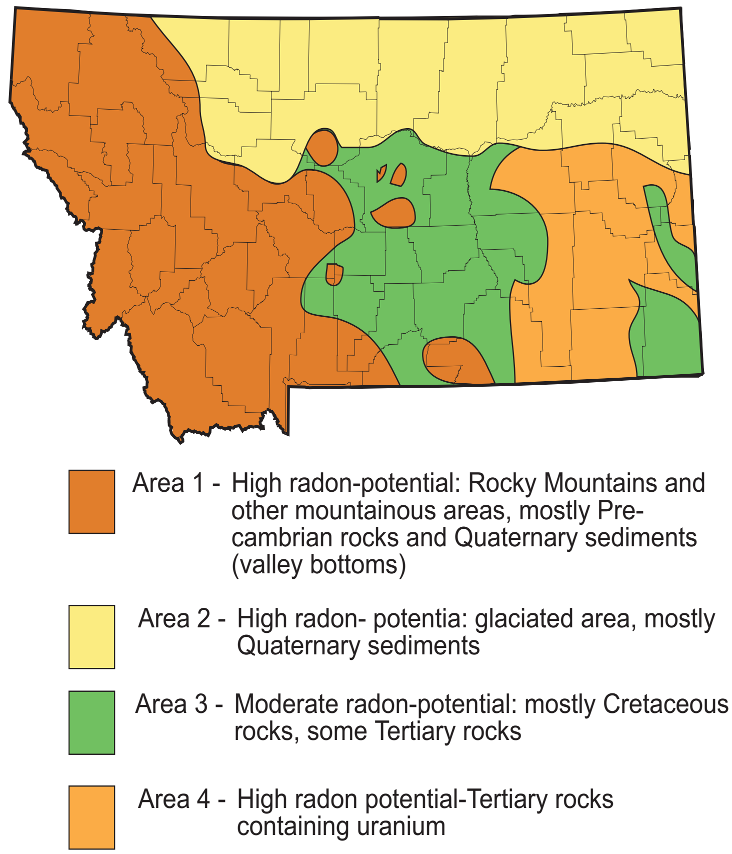
During the **Precambrian** era, which was more than 570 million years ago, one-celled organisms and primitive marine plants developed.

Sedimentary rock is rock of any age formed from the accumulation of grains, which may consist of mineral and rock fragments of various sizes, remains or products of animals or plants, products of chemical action or evaporation, or a mixture of these.

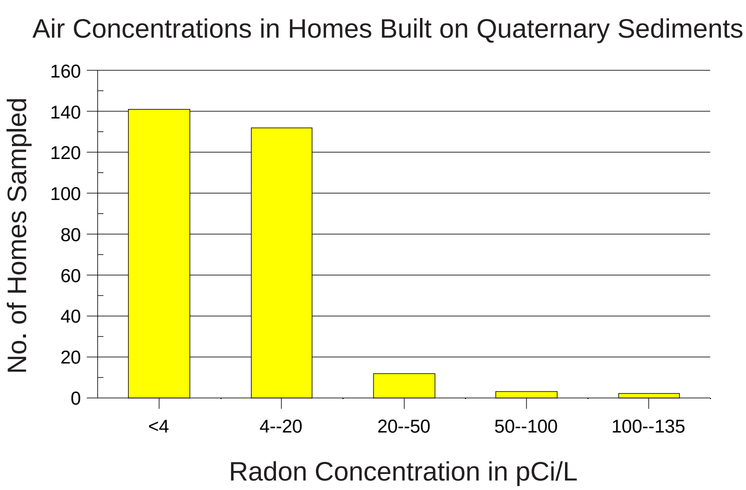
data and architecture type to prepare a map showing radon-potential areas for Montana. The confidence level is based on whether good data are available for a given area.

- **Area 1** consists of the Rocky Mountains and other mountainous areas and has a high radon potential at a high confidence level.
- **Area 2,** the glaciated portion of the Great Plains, has a high geologic radon potential at a moderate confidence level.
- **Area 3,** underlain mostly by Cretaceous rocks and to a smaller extent Tertiary sedimentary rocks, is ranked as moderate radon potential at a moderate confidence level.
- **Area 4,** made up of Tertiary sedimentary rocks that are known uranium producers in Montana and other states, has a high radon potential at a moderate confidence level.

Quaternary, Tertiary, Cretaceous and Precambrian rocks were evaluated using the 1992 MBMG data.

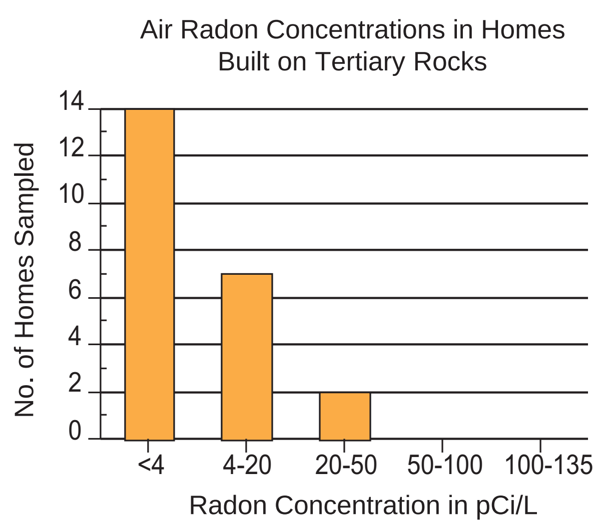


Map showing radon in air potential, *modified from: USGS (1993).*

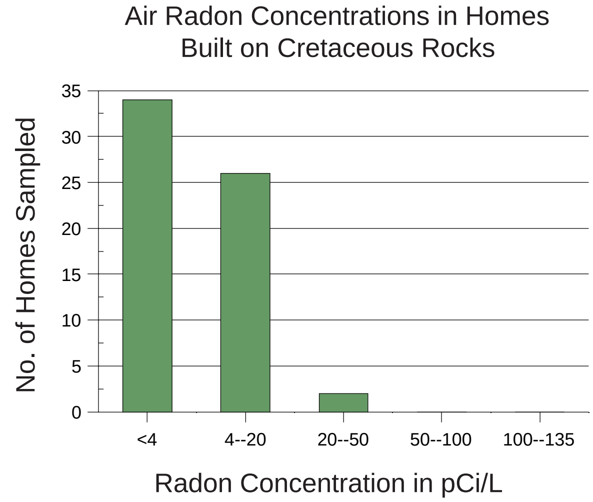


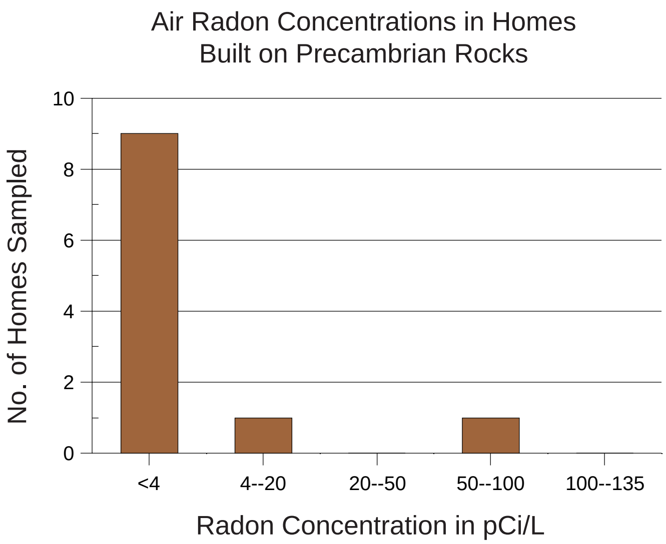
Radon concentrations in homes built on Quaternary sediments (alluvium, lake deposits, glacial deposits, and terrace gravel, etc.) ranged from less than 4 pCi/L to 135 pCi/L. Fifty-one percent of the homes built on Quaternary materials had radon concentrations greater than 4 pCi/L and 6% of the homes showed radon in excess of 20 pCi/L.

Homes located on Tertiary rocks had radon concentrations ranging from less than 4 pCi/L to 50 pCi/L. Of these homes, 39% exceeded 4 pCi/L and 9% exceeded 20 pCi/L.



Radon concentrations measured in homes built on Cretaceous rocks showed about the same distribution as those located on Tertiary units, with concentrations ranging from less than 4 pCi/L to 50 pCi/L. However, 45% exceeded 4 pCi/L and 3% exceeded 20 pCi/L.





Houses built on Precambrian rocks had radon concentrations ranging from less than 4 pCi/L to 100 pCi/L, with only 18 % exceeding 4 pCi/L and 9% exceeding 20 pCi/L.

The average of all of the survey measurements was about 6 pCi/L. Of all the homes screened for indoor radon, concentrations in about 44% were equal to or greater than the recommended level of 4 pCi/L. Based on the survey data, Montana ranks fifth in the United States for indoor radon concentrations greater than 4 pCi/L and third in the United States for concentrations greater than 20 pCi/L.

Radon Hydrogeology in Montana

Many water wells in Montana contain high levels of radon. Data from the Ground-Water Information Center (housed at MBMG), indicate that out of a total of 386 water analyses, 103 wells (27%) contain radon in concentrations under 300 pCi/L, 271 wells (70%) showed radon between 300 and 3,000 pCi/L, and 12 wells (3%) contained radon in excess of 3,000 pCi/L.

There is a correlation between the concentration of radon in ground water and the geology of an aquifer. The following maps show locations and radon levels of 217 wells from 5 aquifers commonly used in Montana:

- **Quaternary sediment** (includes alluvium, glacial deposits and lake-bed deposits)
- **Tertiary rocks**
- **Cretaceous Fox Hills-Hell Creek Formation**
- **Cretaceous Eagle–Virgelle Formation**
- **Cretaceous Kootenai Formation**

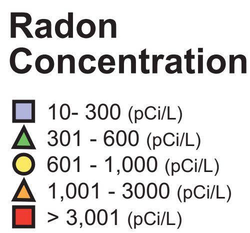
Seventy percent of wells tested have radon concentrations between 300 pCi/L and 3,000 pCi/L.

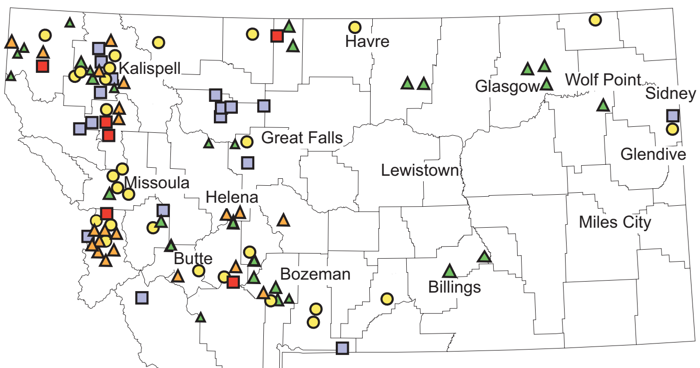
While it is useful to correlate geology with radon occurrence, only testing individual homes can determine whether radon poses a problem at a specific location.

Of these aquifers, none of the wells in Cretaceous sediments contained water with radon concentration greater than 3,000 pCi/L. But wells in the Quaternary sediments and in the Tertiary rocks showed concentrations ranging from 10 to 14,000 pCi/L.

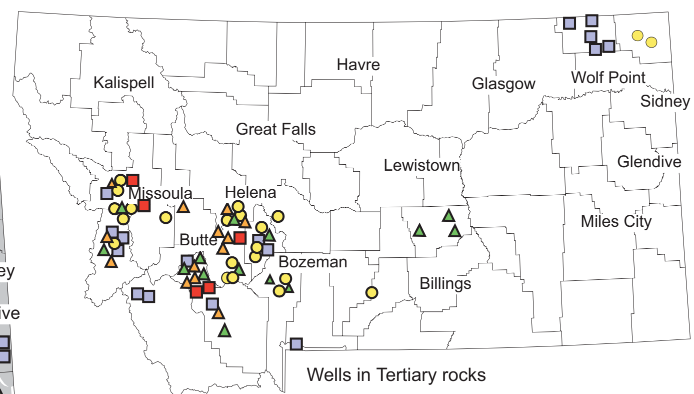
There are large variations in ground-water radon levels, even in the same aquifers and adjacent locations. Although the mapping of rock and soil types can aid in identifying areas of greater risk, only the testing of individual water supplies can determine whether radon from water poses a problem at a specific location.

Radon Concentrations in Five Common Aquifers

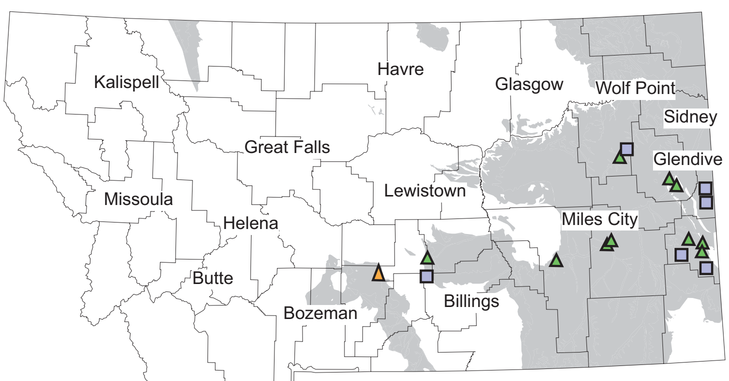




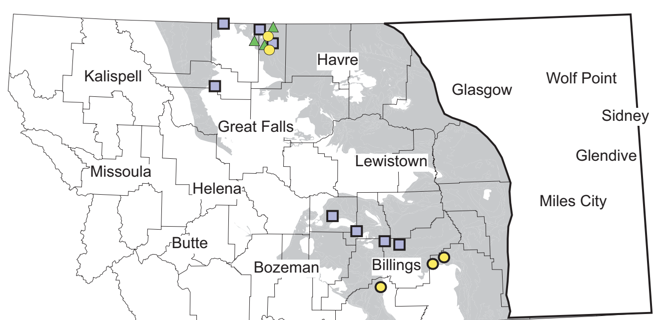
Wells in Quaternary sediments



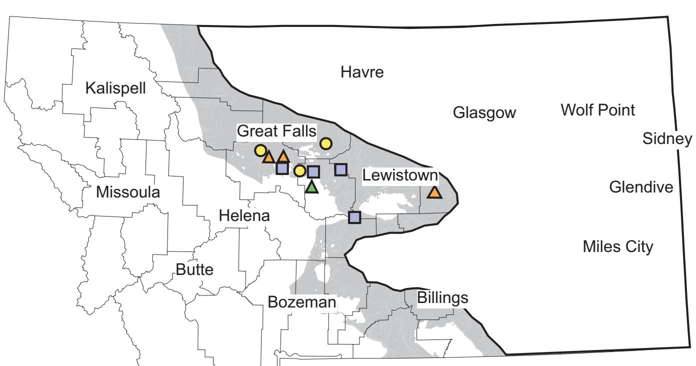
Wells in Tertiary rocks



Wells in the Cretaceous Fox Hills-Hell Creek Formation



Wells in the Cretaceous Eagle / Virgelle Formation



Wells in the Cretaceous Kootenai Formation

How Do I Test for Radon?

Testing Air in Homes for Radon

Radon gas can penetrate houses from many sources in many fashions. It is not possible to radon-proof a home, but it is possible to reduce its level to below 4 pCi/L. The most important contributor to indoor radon is the soil from which radon can be drawn through gaps in the house floor and foundation. Houses that are in direct contact with the ground will have higher radon levels than houses with an air space under the dwelling. Radon levels in the upper floors of a multi-story building are usually lower than on the ground floor. The concentration of radon in your home should be measured and the appropriate action taken if the level is found to be greater than 4 pCi/L, based on an annual average.

Radon measurement is simple, relatively inexpensive, and can be done in many ways. Charcoal canisters remain the method of choice for use by the average homeowner. There are three classes of measurement techniques used:

- *grab sampling,* which provides instantaneous measures of radon or radon daughters in air. Because values fluctuate widely depending on various factors, grab sampling techniques are used in industrial monitoring.
- *continuous active sampling,* which involves multiple measurements at closely spaced time intervals over a long period. These are costly and recommended only when other measures indicate a problem and the source of radon entry needs to be pinpointed precisely.
- *integrative sampling,* which involves data collection on radon levels over a fixed period of time.

Typical devices used for integrative sampling are charcoal canisters and alpha track detectors. The charcoal devices come in a canister which is opened and placed in various locations. Radon in air flows into the canister and is adsorbed onto the charcoal. Following an exposure for 2–7 days, depending on the device and its user instructions, it is returned to the supplier who counts the gamma rays from the

A Glossary of Testing and Mitigation Terms

Alpha track detectors are devices used to locate the alpha particles emitted from the radon decay products.

Charcoal canisters are a special container used for short-term testing—on average 2–7 days.

Long-term testing is air sampling conducted for more than 90 days. Using this test, your home's annual average for radon levels is more accurate than a short-term test.

Short-term testing is air sampling that usually spans a period of from 2 to 90 days. It is wise, however, to follow the test with a second short-term testing before you decide to mitigate.

Soil gas in the pore spaces of the soil is where radon concentrations may be found.

Stack effect is the overall upward movement of air inside a building that results from heated air rising and escaping through openings in the building, thus causing indoor air pressure in the lower portions of a building to be lower than the pressure in the soil beneath or surrounding the building foundation.

Aeration is a process where radon-laden water is impregnated with air, causing the radon gas to be removed from the water into the atmosphere.

radon daughters. Radon has a half-life of 3.8 days, therefore, if the canisters are exposed for several weeks, the results will indicate the radon levels sampled toward the end of the measurement period.

It is important to remember that in Montana, once a radon test has been performed on your home, you are required to disclose the results of the test to potential buyers if you decide to sell your home.

Testing Air in Schools for Radon

Children are more susceptible to radon exposure than adults because of their higher respiratory rates. They also have more years to live, which allows a longer time for cancers to develop. It is suspected that children's cells are more defenseless against radiation damage because their cells divide faster than those of adults.

High radon levels have been found in many schools across the country. Therefore, it is important that students, teachers, and parents be aware that a potential problem could exist. A nationwide survey of radon levels in schools estimates that nearly one in five schools has at least one schoolroom with a short-term radon level above the recommended level of 4 pCi/L. EPA estimates that more than 70,000 schoolrooms in use today have high, short-term radon levels, indicating that a mitigation program should be considered.

Testing for radon is simple and relatively inexpensive. EPA has published guidance that is available free to schools throughout the country. Call the Montana Department of Environmental Quality or the Montana Radon Hotline. These phone numbers may be found at the end of this document.

If a schoolroom fails the radon test, the problem can be corrected. Proven techniques are available that will lower radon levels and lower risks of lung cancer from radon exposure.

The basic elements of school testing are:

- ***test all frequently used rooms on and below the ground level.***
- ***Conduct tests in the cooler months of the because windows and doors are more likely to be kept closed.***
- ***Follow the School Testing Strategy below.***

School Testing Strategy:

Step 1: Initial Testing:

- Take short-term tests.

Step 2: Follow-up Testing:

- Take a second short-term test in rooms where the initial level is 4 pCi/L or higher.
- Take a long-term test in these rooms for a better understanding of the school-year average radon level.

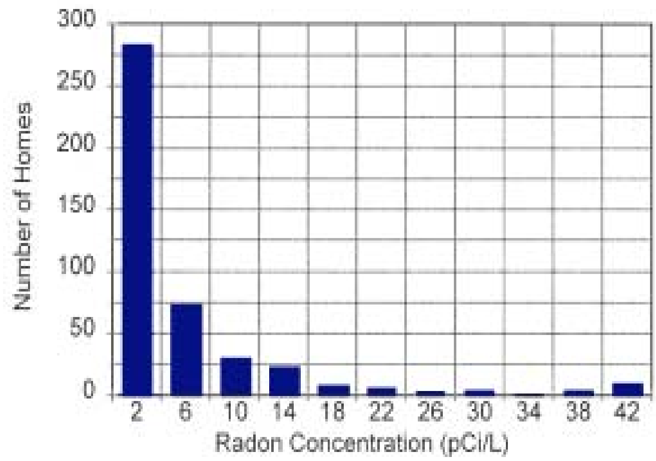
Step 3: Decision Making

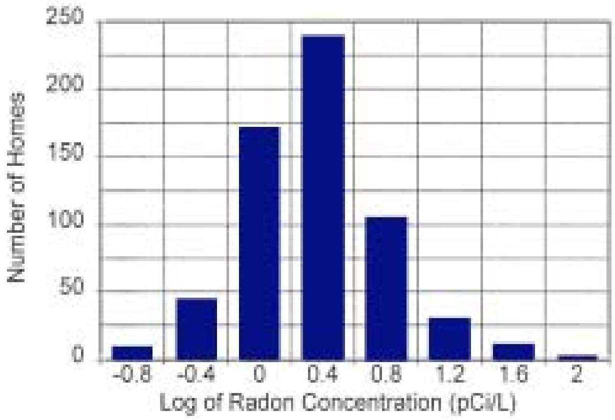
- Take action to reduce levels if the average of the initial and short-term follow-up test is 4 pCi/L or greater or the result of the long-term test is 4 pCi/L or greater.

Testing for Radon in Water

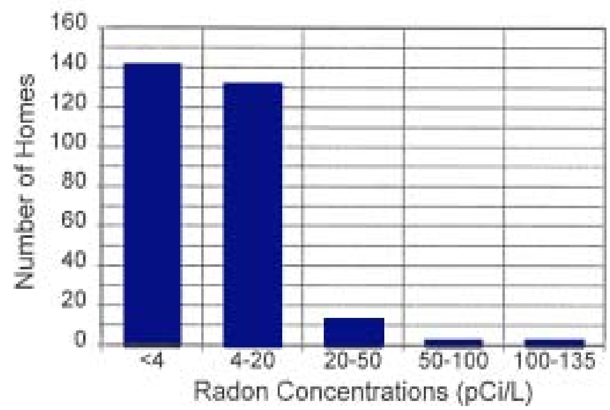
Because radon is a gas, the sampling and measurement of radon in water is complicated. The basic principle hinges on the fact that radon can be lost by aeration; therefore it is important to avoid exposing the sample to the open air. Most homeowners decide to have a trained expert perform water sampling. The sampling method involves:

1. making sure that you are **NOT** sampling after water has passed through a treatment device like a water softener or a reverse osmosis unit;
2. pumping the well until fresh, aquifer water (water that hasn't been sitting in the well casing) is coming out of the sampling hose (typically about 20 minutes for most household wells);

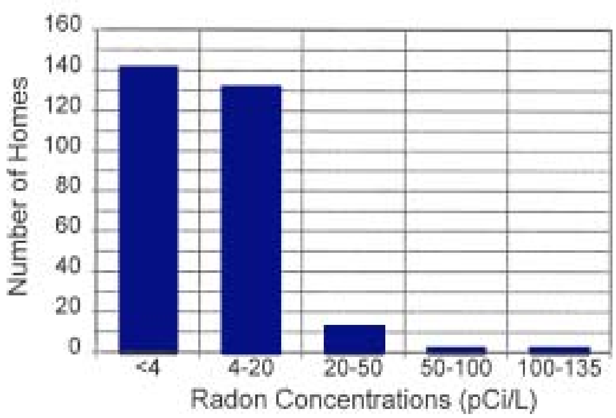




3. filling a bucket until it overflows, and then using a syringe and needle to extract 10 milliliters of water from the inside of the hose while water is flowing.



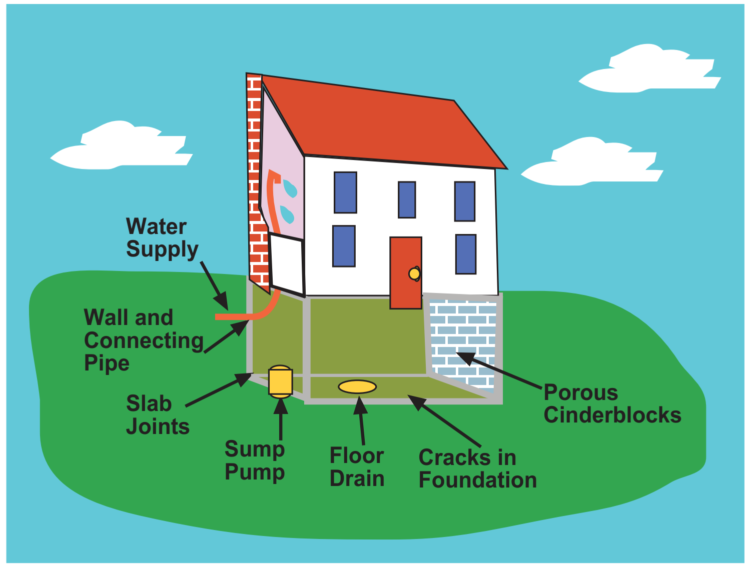
4. dispensing the sample into a vial containing a mineral-oil based substance called a scintillation cocktail, which is an oily compound that prevents the radon from escaping into the air inside the vial.



5. shaking the vials and recording the exact time and date of sampling. The vials are then delivered to the lab within 48 hours.

How Does Radon Enter a Home Through the Air?

In order for radon to enter a home, there must be a difference in air pressure between the indoor air and the outdoor air. The pressure differences can be caused by furnace combustion, ventilation devices, or the stack effect.



Radon-Resistant Construction for New Homes

Residential buildings should be designed and constructed to minimize the entrance of soil gas into the living space, and should be constructed with features that will ease post-construction radon removal or further reduction of radon entry if installed prevention techniques fail to reduce radon levels below 4 pCi/L. The design and installation of radon-control systems should be performed or supervised by a radon professional. EPA recommends that state and local organizations collect and analyze local indoor radon measurements, and assess geology, soil parameters and housing characteristics.

Mitigation is one of a variety of strategies used for reducing radon.

Common foundations that have been studied are basement and slab-on-grade, crawlspace, and combination foundations.

When mitigating radon levels in new or existing homes, contractors concentrate on sealing those air passages where radon can penetrate:

- foundations and floors
- openings around chimney flues
- plumbing
- duct work
- electrical wires and fixtures

Mitigating Radon in Air

Currently there are no U.S. statutory limits covering naturally occurring radioactive materials such as radon and its progeny. However, the EPA developed the Radon Mitigation Standards (RMS) in response to the 1988 Indoor Radon Abatement Act (IRAA). The purpose of the standards is to provide contractors who work with radon mitigation with uniform standards that will ensure quality and effectiveness in the design, installation, and evaluation of radon mitigation systems in residential buildings three stories or less in height. At this time, the RMS does not include standards for installing systems to mitigate radon in water.

Once a home is tested and found to exceed radon levels, a mitigation strategy must be developed. Only approved Mitigation Service Providers should be hired for the task of mitigation in your home.

Only approved Mitigation Service Providers should be retained for the task of mitigating your home.

Major attention is given to methods in which natural or forced ventilation is used to reduce indoor levels of radon gas. These methods range from simply opening windows, to increasing ventilation in homes with low but elevated levels, to forced ventilation systems when higher levels need to be mitigated. In winter, two-fold reductions in radon concentration can be obtained by the use of simple household fans, such as those commonly used in the summer for cooling.

Techniques for Mitigating Radon in Air in your Home

Covering exposed earth reduces radon entry, as does sealing cracks and openings in ground-level walls and floors. Below are some of the ways in which radon levels can be reduced in your home. It is important that your mitigation contractor review the various techniques with you before the project is begun. Costs range from relatively inexpensive ($100) to costly ($2,500) (1998 prices).

Common Mitigation Techniques

Active soil depressurization–There are three depressurization systems that can be used to reduce your home's radon levels:

1) **Sub-membrane depressurization** in crawlspace–This system collects radon as it rises and before it has the opportunity to enter the crawl space. This method can reduce radon levels 80%–99%, in addition, less heat loss occurs than with natural ventilation.

2) **Sub-slab suction (sub-slab depressurization)**–Sub-slab "suction" is more difficult to accomplish because it involves placing pipes under the house (laterally through side walls or by drilling holes in the concrete slab. A fan is used to vent these pipes away from the house. The walls of concrete block houses can be vented by drawing air from the hollow spaces in the wall and venting it away from the house to prevent radon from entering by this route. However, the reduction is about 80%–99%, and it works best if air can move easily in the material under the floor slab.

3) **Sump hole suction**–Sump depressurization is used to collect the radon from a drainage system and release it into the outdoor air. This very reliable technique provides a 90%–99% reduction in your radon levels, and works best if air can move easily to a sump under the slab or if drain tiles form to complete a loop.

Block-wall suction–This method is used only in homes with hollow block walls, where a vacuum is created in the walls; it reduces levels about 50%–99%.

Drain-tile suction–Drain tiles can be placed around the foundation and the air vented away from the house. This technique can provide as much as a 90%–99% reduction in radon levels and works best if the drain tiles form a complete loop around the house.

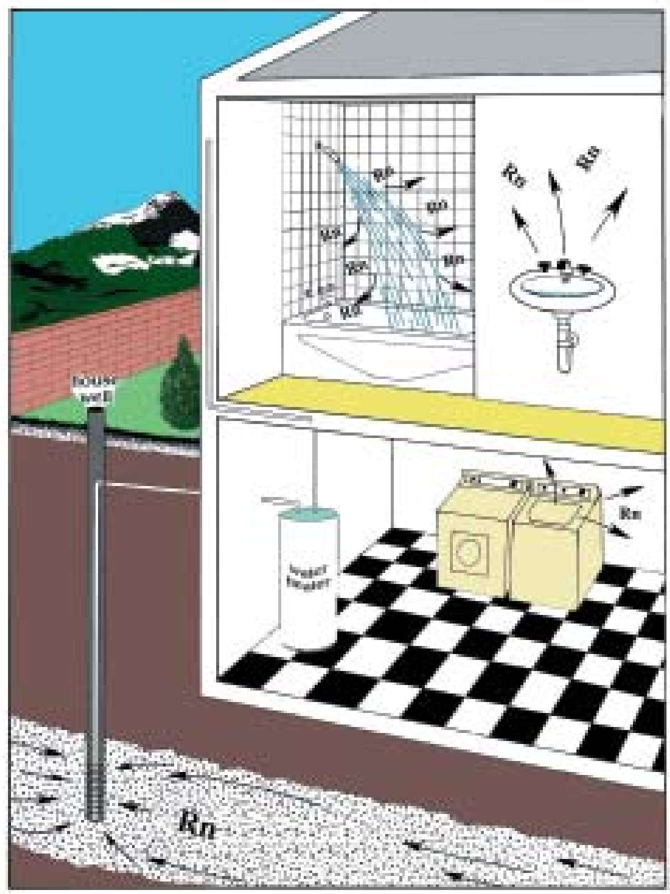
Natural ventilation–There are several disadvantages to using this technique For example, the reduction levels are variable, and there is significant heat and conditioned air loss. The operating cost depends on utility rates and amount of ventilation.

Natural ventilation in a crawlspace–Once again the costs are variable with this method and the reduction level is lower, 0%–50%.

When a mitigation project is completed, your contractor should provide you with an information package that includes the following items:

1. Any building permits required by local codes.
2. Copies of the Building Investigation Summary and a sketch of the floor plan.
3. Pre- and post-mitigation radon test data.
4. Copies of contracts and warranties.
5. A description of the mitigation system installed and its basic operating principles.
6. A description of any deviations from the RMS or State requirements.
7. A description of the proper operating procedures of any mechanical or electrical systems installed, including manufacturer's operation and maintenance instructions and warranties.
8. A list of appropriate actions for clients to take if the system failure warning device indicates system degradation or failure.
9. The name and telephone number of the radon professional and the telephone number of the state radon office.

How Does Radon Enter a Home Through Water?



Because radon is a gas, it can move underground and can enter buildings through cracks in foundations. Because radon is soluble in water, it can also enter ground water and be drawn into water-supply wells. Radon that enters homes in well water can either be ingested directly in water used for drinking and food preparation, or released into the air at faucets and shower heads then inhaled.

Most Montanans rely on ground water from wells as their only source of household water. For those homes having private water supplies, it is the home owner's decision whether to test or treat their water.

Although radon can get into some homes through the water, you should test the air in your home for radon first. If tests of the air in your home show that radon levels exceed 4 pCi/L on an annual average and you suspect that your household water supply may be the cause, you should contact the Montana Department of Environmental Quality for assistance in testing your water.

Mitigating Radon in Water

The two commonly accepted practices for removing radon from water are aeration and the use of activated carbon filters. Activated carbon filters for private water supplies may be purchased from most water-treatment retailers. Aeration systems cannot be housed indoors, and they require more extensive design and installation procedures.

Possible Requirements for Public Water Supplies

For people using water from a public water supply, there may be some issues that your water utility will face. As previously mentioned, the EPA is currently proposing standards, or maximum contaminant levels (MCLs) for radon in public drinking water supplies. These standards address health risks from both inhalation and ingestion of radon. Pending the results of a study by the National Academy of Sciences, two MCLs are being proposed; the MCL at 300 pCi/L and an Alternative MCL at 3,000 pCi/L. Under the proposed rules, many public water supplies will be required to test for radon. Examples of regulated public supplies include towns, trailer parks, subdivisions, schools, and hospitals. If a public water supply contains radon at levels less than 300 pCi/L, no action would need to be taken. If the radon concentration is between 300 pCi/L and 3,000 pCi/L, the public supply would be required to inform the public about radon mitigation and the risks of radon from air and water. If radon concentrations exceed 3,000 pCi/L, the public water supplier would be required to treat the water to remove radon.

Where Can You Go For More Information?

Agencies:

Montana Department of Environmental Quality
Planning, Prevention and Assistance Division
Metcalf Building
Helena MT 59620
406-444-6697

Montana Radon Hotline
1-800-546-0483

National Safety Council Radon Hotline
1-800-557-2366

U.S. EPA Clearinghouse Indoor Air Quality
1-800-438-4318

U.S. Environmental Protection Agency, National Radon Hotline
1-800-SOS-RADON
internet: www.epa.gov

American Lung Association
1-800-LUNG-USA (1-800-586-4872)
internet: www.lungusa.org

Publications:

Swaggert (1996), EPA 402-R-93-046, or USGS 93-292-H, for an evaluation of radon levels by county, cited at the end of this document.

All of the radon in air results have been compiled on a map, “Radon in Indoor Air in Montana” (MBMG 328) that is available from the Montana Bureau of Mines and Geology, Publication Sales Office, 1300 West Park St., Butte MT 59701, 406-496-4167.

Among other pamphlets that can be reviewed on their web page, the EPA has published the:

Citizen’s Guide to Radon - EPA Document #402-K92-001
U.S. Government Printing Office
Superintendent of Documents, Mail Stop: SSOP
Washington D.C. 20402-9328
ISBN0-16-036222-9

For information about testing for radon in water contact:

Montana Department of Environmental Quality
Planning, Prevention and Assistance Division
Metcalf Building,
Helena MT 59620,
406-444-6697

Montana Bureau of Mines and Geology
Analytical Division
1300 W. Park St.
Butte MT 59701
406-496-4753

U.S. Geological Survey
301 S. Park Avenue
Helena MT 59620
406-441-1329

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Miller, K.J., 1994, Radon in indoor air in Montana, winter 1992 survey results, MBMG 328.

Swaggert, K.H., 1996, Evaluation of radon in indoor air and ground water throughout Montana, M.S. thesis, Montana Tech of The University of Montana, 76p.

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U.S. Environmental Protection Agency, 1992a, A citizen's guide to radon (Second Edition) - the guide to protecting yourself and your family from radon: U.S. EPA pamphlet ANR-464, 15p.

U.S. Environmental Protection Agency, 1993, EPA's Map of Radon Zones, Montana, EPA 402-R-93-046, 73p.

U.S. Geological Survey, 1993, Geologic Radon Potential of EPA Region 8, USGS 93-292-H, 184p.

Wiens, G., 1998, Montana Department of Environmental Quality, personal communication.