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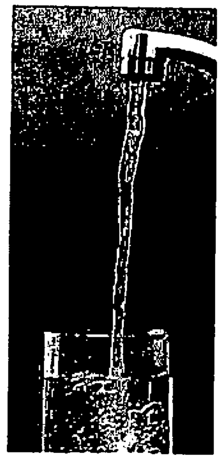
Residential Waterborne Radon Removal Study Using Granular Activated Carbon (GAC) Filtration Systems



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US Radon Systems™
Nationwide Radon Reduction Experts

Outline

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Proposed Federal and State Waterborne Radon Guidelines
Waterborne Radon Removal Using GAC Filtration Systems
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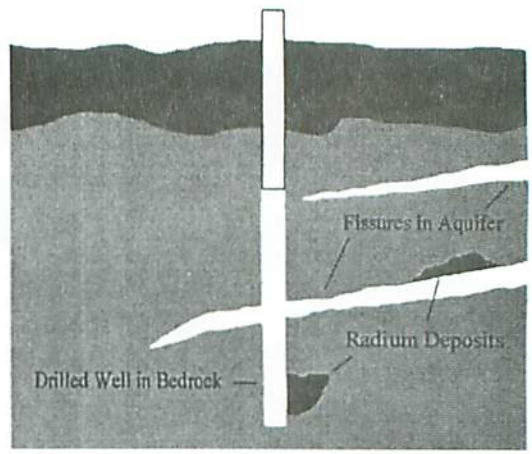
Interpretation of Results and Conclusions

Introduction to Waterborne Radon

Origin of Waterborne Radon

Radon is a radioactive gas that cannot be seen, smelled, or tasted. Radon gas comes from the natural decay of uranium in the rocks and soil. Uranium breaks down into radium and radon is the decay product of radium.



The gas is measured in picocuries per liter (pCi/l). A curie, which gets its name from Madame Curie, is a representative of the radioactivity associated with one gram of radium. A picocurie is one trillionth of a curie. Finally, a picocurie per liter refers to an amount of radioactivity that emits 2.22 disintegrations per minute in a one liter volume of air.

Radon's Health Effects

When radon escapes into the open air, it is harmless. However, when the gas enters into the living areas of buildings and accumulates, it becomes a deadly threat. The decay products of radon can lodge in the lungs and increase the risk of lung cancer. For this reason, the USEPA has set the guideline for indoor air of 4.0 pCi/L.

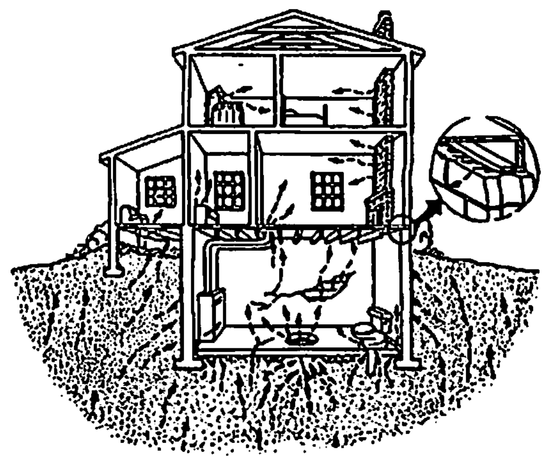
The US Surgeon General has warned that radon is the second leading cause of lung cancer in the United States today contributing to about 20,000 lung cancer deaths each year. The EPA estimates that 168 cancer deaths per year are caused by radon in drinking water. They estimate that 89 percent is lung cancer caused by the breathing of radon released from the water and 11 percent is stomach cancer caused by drinking radon-laden water.

Pathways into a Building

Radon enters the average home or building as a result of decaying radium present in the soil and bedrock surrounding the building. Homes or other buildings with well water offer another radon entry route. Radon can enter directly into the living areas of the building by escaping into the air when faucets, showers, washing machines, etc., are in use.

As a general rule, the USEPA has suggested that 10,000 pCi/L as measured in the water will contribute 1.0 pCi/L throughout the household air. This will vary largely due to the amount of water used and the proximity to the point of use. In rooms where large amounts of water are used, the airborne radon will greatly exceed the 10,000 to 1 ratio.

Radon Entry Routes



Testing for Waterborne Radon

Each lab will have their preferred method of sampling. All, however, require an air free sample be drawn to assure accuracy. Contact the lab of choice for test kit availability and proper sampling procedures. Keep in mind, liquid scintillation is listed by the EPA as the best available technology (BAT) for waterborne radon testing.

Proposed Federal and State Waterborne Radon Guidelines

Safe Drinking Water Act

On August 6th, 1996, President Clinton signed into law the Safe Drinking Water Act Amendment of 1996. Section 109 covers the topic of radon and, in short, legislates that a regulation for municipal waterborne radon be set by August 2000. This legislation is currently pending.

As part of the SDWA, the National Academy of Science (NAS) was charged with determining, among other things, the average outdoor radon level and to then recommend an alternate maximum contaminant level (AMCL) based on their findings. From this research, the EPA proposed in October 1999 a maximum contaminant level (MCL) of 300 pCi/l and an AMCL of 4,000 pCi/L.

States can develop Multimedia (MMM) programs that address health risks from radon in air, which would allow the use of 4,000 pCi/L as the state standard. States that do not have an MMM will be required to use 300 pCi/l as the state standard. Individual water systems, however, can develop a their own local MMM and use 4,000 pCi/L as a standard in that local water district. All MMM programs will be reviewed and approved by the EPA to determine proper radon risk reduction goals are being achieved.

State Recommended Waterborne Radon Guidelines

Until the federal guideline for waterborne radon is implemented, State Radon Programs will be responsible for setting recommended guidelines. Currently, many states have yet to adopt a recommended policy. Every state does, however, recommend the testing of airborne radon and if the radon levels are not entering through the soil to test the water.

Connecticut	5,000 pCi/L
Rhode Island	5,000 pCi/L
Massachusetts	10,000 pCi/L
New Hampshire	2,000 pCi/L
Vermont	10,000 pCi/L
Maine	20,000 pCi/L
New York	Waiting for Federal Standard
Pennsylvania	Waiting for Federal Standard

As the concern about waterborne radon has grown, testing during real estate transactions has become common in many states. Consequently, this has lead to a large number of homes being treated. The passage of the Safe Drinking Water Amendment will further heighten public awareness. Those states that do not yet have a recommendation may find themselves setting an interim recommended guideline due to public pressure.

To find out your state's position on waterborne radon, contact your state radon program, Department of Health, or Office of Environmental Radiation.

U.S. Radon Contacts

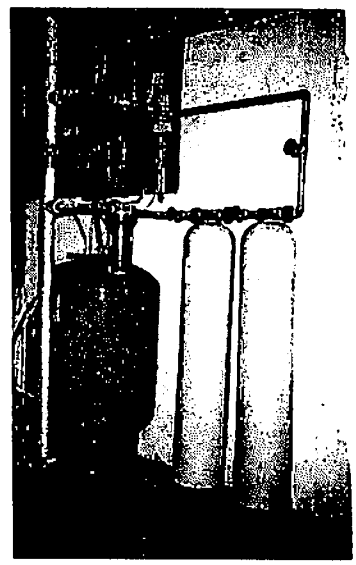
Alabama	(800) 582-1866
Alaska	(800) 478-8324
Arizona	(602) 255-4845
Arkansas	(800) 482-5400
California	(800) 745-7236
Colorado	(800) 227-8917
Connecticut	(860) 509-7367
Delaware	(800) 464-4357
District of Columbia	(202) 442-8993
Florida	(800) 543-8279
Georgia	(800) 745-0037
Guam	(671) 475-1611
Hawaii	(808) 586-4700
Idaho	(800) 445-8647
Illinois	(800) 325-1245
Indiana	(800) 272-9723
Iowa	(800) 383-5992
Kansas	(800) 693-5343
Kentucky	(502) 564-4856
Louisiana	(800) 256-2494
Maine	(800) 232-0842
Maryland	(410) 631-3801
Massachusetts	(800) 723-6695
Michigan	(800) 723-6642
Minnesota	(800) 798-9050
Mississippi	(800) 626-7739
Missouri	(800) 669-7236
Montana	(800) 546-0483
Nebraska	(800) 334-9491
Nevada	(702) 687-5394
New Hampshire	(800) 852-3345
New Jersey	(800) 648-0394
New Mexico	(505) 827-1563
New York	(800) 458-1158
North Carolina	(919) 571-4141
North Dakota	(800) 252-6325
Ohio	(800) 523-4439
Oklahoma	(405) 702-5100
Oregon	(503) 731-4014
Pennsylvania	(800) 237-2366
Puerto Rico	(787) 767-3563
Rhode Island	(401) 222-2438
South Carolina	(800) 768-0362
South Dakota	(800) 438-3367

Tennessee	(800) 232-1139	Washington	(360) 664-4536
Texas	(800) 572-5548	West Virginia	(800) 922-1255
Utah	(800) 458-0145	Wisconsin	(888) 569-7236
Vermont	(800) 439-8550	Wyoming	(800) 458-5347
Virginia	(800) 468-0138		

Waterborne Radon Removal Using GAC Systems

Granular Activated Carbon Filtration (GAC)

The GAC system adsorbs radon from the water without the use of mechanical components. The radon molecules pass through the GAC filter bed(s) and are adsorbed in the pores and on the outer surface area of the carbon.



GAC System Configuration

Typical residential system designs will utilize one, two, or three filter tanks plumbed in series, depending on the severity of the waterborne radon level being treated. Sediment filters are also installed before and after the GAC tanks. The pre-filter is used to screen sediment and minimize contaminant entry onto the GAC bed. The post-filter is used to prevent the small carbon particulate, or "fines", from entering the household water supply. GAC systems, when properly sized and installed, can yield 90+% reduction of radon when initially installed.

Other contaminants in the water, including iron, manganese and lead, can adversely affect the radon removal efficiency of the GAC system over time. These types of contaminants are also being adsorbed by the carbon, which will leave less surface area for the adsorption of radon. Pre-treatment for these types of contaminants is recommended if they are above acceptable levels.

A conservative approach when sizing, installing, and servicing GAC systems is recommended. Fluctuations in waterborne radon levels and bio fouling can also cause unfavorable radon removal (less than 80% removal efficiencies) within one year. Annual carbon re-bedding is minimally required for continued performance.

The EPA does not consider GAC systems the Best Available Technology (BAT) for waterborne radon removal due to the performance issues and the potential for radionuclide (gamma) build-up on the carbon beds. Furthermore, the EPA does not recommend the use of carbon filtration for waterborne radon levels exceeding 5,000 pCi/L.

Study of GAC System Performance Over Time

Residential Field Study

We recently conducted a field study at a number of residences with GAC filtration systems in place. The purpose of this study was to sample the removal efficiencies of GAC systems after they have been in service for one year, and immediately after the annual service. The annual service includes a rotation of the existing tanks, a replacement of one carbon tank, replacement of the pre and post sediment filter cartridges, and a post service waterborne radon test to verify removal efficiencies.

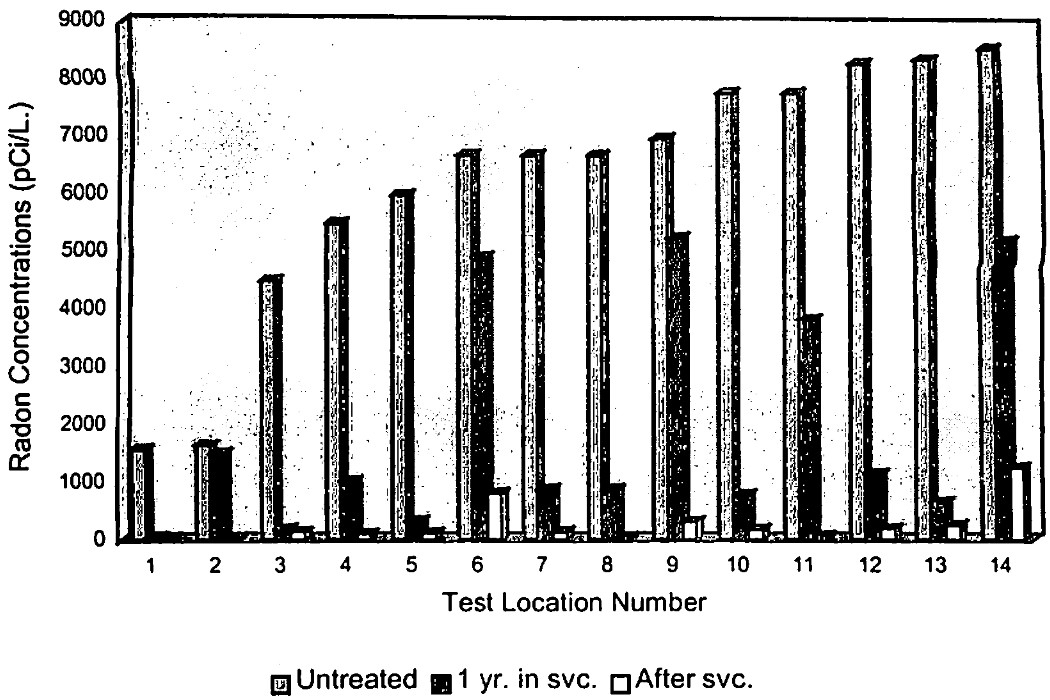
For the purposes of this study, we also performed a waterborne radon test prior to servicing the system in addition to the post service test. Duplicate and blank sampling was also done on a percentage of the tests to further substantiate the data.

All of the GAC systems were in service for approximately one year at the time of data collection. They were each serviced in a similar fashion by our team of qualified technicians. The waterborne radon tests were performed as per the instructions, and sent out to an independent laboratory for analysis. Results were categorized by property address and test device serial number to verify untreated, pre-service, and post-service water samples.

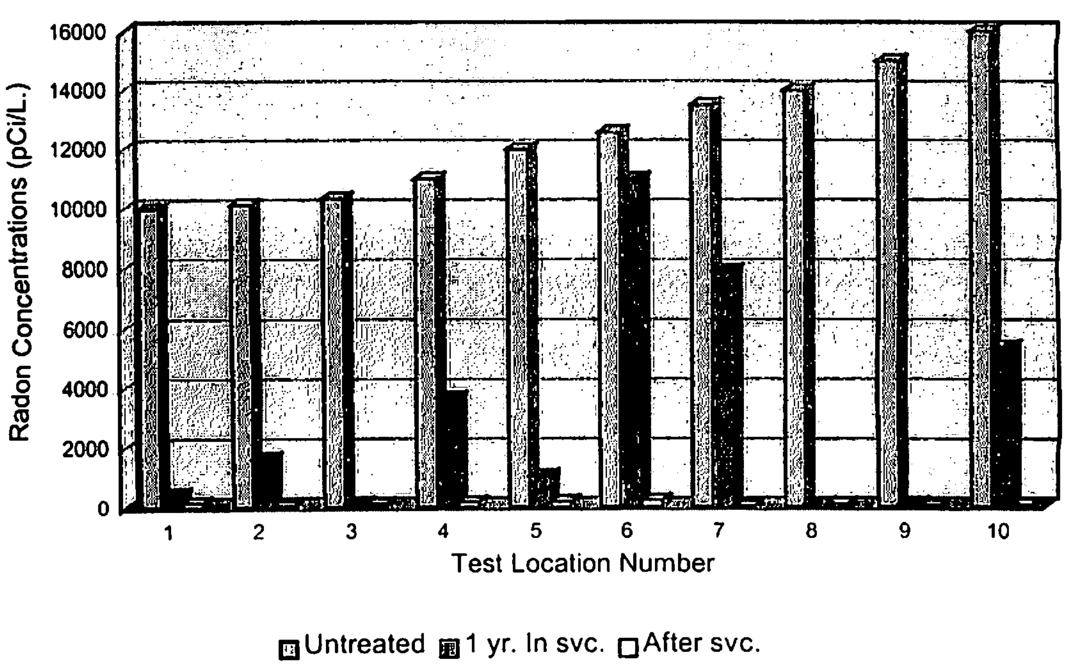
Overall water quality (potability) testing was also performed on the water entering the GAC systems. This was performed to assess whether a presence of other contaminants directly correlated to radon reduction efficiencies over time.

The following tables represent a random sampling of data collected from 50 different GAC systems. Separate tables have been created for two tank and three tank GAC systems.

Radon Reduction Using 2 Tank GAC Systems



Radon Reduction Using 3 Tank GAC Systems



Interpretation of Test Results and Conclusions

Field Study Results

The results of this field study reveal that there can be a great disparity in GAC system performance from one location to another. Different test locations with similar untreated radon levels can yield vastly different radon removal efficiencies over time.

Thirty-five percent of the 2 tank GAC systems, and forty percent of the three tank GAC systems sampled were not reducing the radon levels by at least 80% after they had been in service for one year.

Of all the GAC systems sampled, less than fifteen percent were reducing radon levels by 90% or better after being in service for one year, while every system achieved 90+% removal efficiencies when they were initially installed.

Overall water quality testing indicated the majority of test locations had favorable water quality for the performance of GAC systems. No definitive correlation could be made to the presence of contaminants affecting radon removal efficiencies. Many of the test locations had pre-treatment systems in place before the GAC systems; therefore the presence of other contaminants had already been minimized.

Conclusions

The data obtained in this study indicates that there is the potential for less than satisfactory radon removal over time when using GAC systems. There are, of course, many variables to take into consideration when looking at the data. Variable site specifics, such as water flow rates, gallons of water used per day, and fluctuating influent radon concentrations can all impact the performance of GAC systems.

One remedy to minimize the drop-off in removal efficiencies would be to replace the GAC tanks at more frequent intervals, or replace all the tanks annually. However, due to the increased service costs associated with this type of maintenance, in many instances, it may not be economically feasible.

Installers and users of GAC systems need to be aware of the potential for diminishment of GAC performance over time. Periodic waterborne radon testing should be performed to ensure that the desired radon removal efficiencies are being maintained.