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Monitoring Radon as a Vapor Intrusion (VI) Tracer or Surrogate

What is Radon and Why Measure it at a Volatile Organic Compound (VOC) Contaminated Site?

- Radon is colorless, odorless, naturally occurring gas that is a common component of soil gas.
- Radon has few indoor sources, and thus is a relatively unique tracer of soil gas intrusion into buildings, following the same pathway to indoor air as soil gas and with very similar mechanisms as VOCs in soil gas.
- Radon exposure poses very substantial carcinogenic hazards in and of itself, so reducing radon is a valuable side benefit of mitigating the VI pathway (for more information, see https://www.epa.gov/radon/health-risk-radon).
- Radon is measured in picocuries per liter (pCi/L) or becquerels per cubic meter (Bq/m^3): 1 pCi/L = 37 Bq/m^3.
- EPA recommends mitigation of residences with radon levels greater than 4 pCi/L and consideration of mitigation at levels between 2 and 4 pCi/L.

Where to Measure Radon?

- Radon can be monitored with these methods in crawlspace, ambient, entry pathway, and indoor air.
- Select indoor locations to represent the zones in which exposure likely occurs, such as breathing zone height in occupied basements and first floors.
- Ambient radon in outdoor air can be an important comparison because outdoor radon can significantly contribute to indoor levels. Estimates of ambient air radon in the United States averages 0.4 to 0.7 pCi/L, with concentrations ranging from less than 0.01 to 1.5 pCi/L. Radon in ambient air is higher at night, and usually higher over land then over oceans. Radon seasonality in outdoor air depends on wind direction and precipitation.
- Monitoring of crawlspaces and air in preferential pathways (for example wall cavities) can provide insights to the times and places of soil gas entry. Radon surveys can be used to identify entry points such as functioning cracks.
- Radon is likely to be detectable in soil gas almost everywhere in the United States, but concentrations strong enough to be clearly observable after attenuation into indoor air are most likely in medium to high radon risk areas (Zones 1 and 2 in https://www.epa.gov/sites/production/files/2015-07/documents/zonemapcolor.pdf).
- Very roughly, high risk radon zones are likely to have soil gas radon greater than 1,350 pCi/L and medium risk radon zones range from 270 to 1,350 pCi/L (Lewis and Houle, 2009).

When to Measure Radon? What Can I Learn from It?

- A building radon survey during a site investigation can be used to identify the rooms most effected by VOC VI.
- Radon measurements can help identify potential soil gas entry points **if** VOC VI is occurring when you measure.
- Using a blower door or exhaust fan to depressurize the building can help ensure VI is occurring during the survey.
- A radon survey of multiple buildings across a neighborhood or campus can identify buildings vulnerable to VI.
- Long-term monitoring of radon in indoor air can be used to identify the conditions, such as weather and season when VI is most problematic, and when VOC samples most likely to approximate reasonable maximum exposure could be taken.
- Radon measurements can provide a warning that VI mitigation systems are not working well as long as measurements are taken during the time intervals in question.
- Measurements of radon and VOCs in subslab soil gas can be coupled with indoor air measurements to help distinguish subslab from indoor sources of VOCs (Mosley et al., 2010).
- Record the date and time for every measurement you make.

Power interruptions and daylight savings time. When selecting radon monitoring equipment for long-term projects, determine ahead of time how those devices will react to power outages and time changes due to daylight savings time. These events can affect the accuracy of date/time stamps, especially when comparing data streams coming from multiple independent devices.

How to Measure Radon with Instrumental Devices?

- Consumer-grade long-term monitoring devices are available for purchase for under $200, in some cases with data logging.[1]
- A list of independently certified devices can be found at http://aarst-nrpp.com/wp/certification/approved-devices/.
- Professional-grade devices are widely available for rent from environmental equipment companies.[2]

Example Consumer-Grade Instrumental Radon-Measurement Devices



Example Professional-Grade Instrumental Radon-Measurement Devices




How to Measure Radon with Integrating Devices?[3]

- Charcoal with analysis by liquid scintillation in lab. Typical price is $17 to $25 per sample, lower in bulk ($11.50). Typical sampling time is 2 to 7 days with a 0.1 pCi/L detection limit. See for examples: https://www.radonzone.com/product/short-term-radon-test-kit.html and https://www.emsl.com/ProdCatSearchResults.aspx?action=prod&ProductID=rradngtk&Name=radon-gas-test-kit---retail
- Alpha track detectors. Plastic or film device counted in lab; $25 per sample or $22 per sample in bulk. Typically used for longer tests, such as 1 to 12 months. See for example, https://www.rssi.us/sunshop/ and https://www.accustarlabs.com/products
- Electret's. Readable in field with a claimed price of $2 per sample in bulk with starter equipment kit cost of $2,595; different configurations of chambers and electrets tailored to durations from 1 to 365 days
- Lists of certified sources: http://aarst-nrpp.com/wp/certification/database-search/aarst-nrpp-certified-analysis-laboratories/ and http://aarst-nrpp.com/wp/certification/approved-devices/.

[1] Images of examples reprinted from http://radonftlab.com/radon-sensor-product/, https://airthings.com/wave/, and https://www.sylvane.com/safety-siren-pro-series3-radon.html.

[2] Images of examples from https://sunradon.com/products, https://durridge.com/products/rad7-radon-detector/, https://www.femto-tech.com/510LP, and https://airthings.com/pro/?gclid=EAIaIQobChMIyriJ19ys3wIV3LrACh15TAp4EAAYASAAEgIdVfD_BwE.

[3] Photos reprinted from http://aarst-nrpp.com/wp/consumer-devices/ and https://radelec.com/store/index.php.

Example Integrating Radon-Measurement Devices

Where Can I Get More Detailed Information?

ANSI/AARST Methods. *Protocol for Conducting Measurements of Radon and Radon Decay Products in Homes* (MAH-2014), *Protocol for Conducting Measurements of Radon and Radon Decay Products in Schools and Large Buildings* (MALB-2014), and *Radon Measurement Device Requirements* (MS_PC-2015), https://aarst-nrpp.com/wp/store/aarst-standards/

Lewis, R.K., and P.N. Houle. 2009. *A Living Radon Reference Manual.* Pennsylvania Department of Environmental Protection Bureau of Radiation Protection, Radon Division and University Educational Services, Inc. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.371.9318&rep=rep1&type=pdf

Mosley, R.B., D. Greenwell, and C.C. Lutes. 2010. Use of integrated indoor concentrations of tracer gases and volatile organic compounds (VOCs) to distinguish soil sources from above-ground sources. Poster presented at the *Seventh International Remediation of Chlorinated and Recalcitrant Compounds Conference*, Monterey, CA, May 24–27.

Schuver, H.J., and D.J. Steck. 2015. Cost-effective rapid and long-term screening of chemical vapor intrusion (CVI) potential: across both space and time. *Remediation Journal* 25(4): 27-53.

U.S. EPA (Environmental Protection Agency). 1992b. *Indoor Radon and Radon Decay Product Measurement, Device Protocols*. EPA 402-R-92-004, Office of Radiation Programs, Washington, DC, July (revised). https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=94001H1B.txt.

Also see the manufacturer's manuals for any instruments you use.

Sample Data Quality Goals for Indicator Measurements

Measurement	Accuracy	Precision	Range	Sensitivity	Resolution
Radon in indoor, crawlspace, or ambient air	0.3 pCi/L	0.2 pCi/L	0 to 20 pCi/L	0.2 pCi/L	0.1 pCi/L
Radon in soil gas or entry point gas	1 pCi/L	1 pCi/L	0 to 5,000 pCi/L	2 pCi/L	1 pCi/L

For additional information, please contact:

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