

Radon: Environmental Tracer

Carlos Bielicki CEO carlos@durridge.com Dr. Stephen Sadler Chief Scientist stephen@durridge.co.uk



What Is Radon?

- Radon (Rn-222) noble, radioactive gas produced by decay of Uranium-238
- Sketchy reputation...





Two Sides of Radon

HARMFUL Lung Cancer



HELPFUL Environmental Tracer



Environmental Tracer?

- It's everywhere air, soil, rock, groundwater
- Suited to large scale & long term studies
- No perturbation to system being studied
- No risk of environmental contamination
- Precise detectability
- Free!





Use Cases

- Groundwater/surface water interaction
 - Leaching pollutants
 - Salt water and fresh water mixing
- Vapor intrusion
 - PCE in a manufacturing facility
- NAPL (non-aqueous phase liquid) survey
 Diesel fuel contamination



Groundwater/Surface Water Interaction

- Groundwater carries higher radon than rivers, streams, lakes, coastal waters
- Radon measurements can determine existence and locations of groundwater discharge
- Applications
 - Investigation of soil or groundwater contamination
 - Groundwater/surface water interaction studies in marine and freshwater systems
 - Investigation of groundwater migration processes







- Project
 - Exploring for groundwater pathways of pollution in Thailand waterways
 - "Radon very concentrated in groundwater relative to surface waters, thus serves as effective groundwater discharge tracer. We have run surveys of the main river (Chao Phraya) that runs through Bangkok as well as several of the canals (called "klongs") that branch off the river."



From left to right: Gullaya Wattayakorn (Marine Science Dept., Chulalongkorn Univ.), Bill Burnett (FSU), and Supitcha Chanyotha (Dept. Nuclear Engineering, Chulalongkorn Univ.) during a canal survey. There are 3 RAD7s in the box collecting radon data while we are also logging conductivity, temperature, water depth as well as GPS coordinates.







- Method
 - Radon, with a half-life (3.82 days) shorter than the suspected flushing time of the canals, is widely distributed throughout the waterway. It can thus be used to estimate discharge via a mass balance approach but cannot discern precisely where the discharges occur.
 - We are using thoron (220Rn) as a prospecting tool to find points of entry of groundwater into the canals. Thoron, with its rapid decay (56 s half-life), will only occur very close to points of entry. Thus, if one detects thoron in the environment, there must be a source nearby.



Three RAD7s arranged in parallel collect underway radon-in-water activities on 5 to 10-minute intervals.





- Result
 - Nutrient analyses conducted during a time-series experiment at sites of suspected high discharge showed that dissolved inorganic nitrogen and phosphate correlated significantly to radon. It thus appears very likely that seepage of shallow groundwater is an important pathway for nutrient contamination of the klongs, and thus to the river, and ultimately to the Gulf of Thailand.



Thoron distribution along a 25km stretch of Klong Bangkok Noi together with the meaningful thoron threshold (MTT). The peaks labeled 1-4 indicate are all well above the MTT and indicate GW discharge points.

USGS

- Project
 - Examining interactions of fresh and saline water beneath sea floor in near coastal area (Monterey Bay, CA) through radon analysis.
 - Dr. Ferdinand Oberle:
 "We are measuring radon to distinguish if we are looking at just surface run-off, or if it's actually groundwater."



Cordell Johnson and Ferdinand Oberle (USGS) deploying RAD7 buoy. (Photo Credit: F. Oberle)



USGS

Questions? Ferdinand Oberle foberle@usgs.gov

- Method
 - RAD7 radon detection systems employed to measure Rn in air using a water/air exchanger
 - This setup allows for a near realtime calculation of the aqueous Rn concentration by measuring the air 222Rn concentration and knowing the temperaturedependent 222Rn partitioning coefficient
 - USGS-developed RAD7 buoys were tested for this purpose.
- Result
 - Project in process, measurements ongoing

RAD7 buoy in the Monterey Bay, CA (Photo Credit: F. Oberle)

Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government





Polling Question #1

Vapor Intrusion Studies

- How much VOC in building from indoor/outdoor sources vs sub-slab ?
- Radon attenuation factor indicates soil vapor transport through building foundation (slab)
 - Unlike VOCs, there are no significant aboveground radon sources

Attenuation Factor Calculation

$$\alpha = \frac{C_{Rn}(indoor) - C_{Rn}(outdoor)}{C_{Rn}(Soilvapor)}$$

 α = Attenuation factor

 \underline{C}_{Rn} = Concentration of radon

Correct for decay between collection & analysis if sample analyzed by laboratory



If 10% of soil vapor is entering the building and VOC vapor measurement > 10%, then there is an indoor/outdoor VOC source



Vapor Intrusion Studies (cont.)

- Important to measure radon & VOC <u>continuously over time</u> for accurate picture of a building's VI behavior
 Averages are misleading, don't tell the real story
- See EPA presentation slides 23 & 26 : <u>https://iavi.rti.org/assets/docs/01_Schuver%20-</u> <u>%20ITS%202019%20Update%20-%20Oct%2021b.pdf</u>





HQ in PA

Offices in MA, CT, NH, NY, NJ, etc.

- Project
 - Large manufacturing facility in SE Wisconsin had source of PCE (carcinogenic chemical) beneath it
 - Even though samples of indoor air were below levels of concern, sub-slab samples contained PCE above WDNR's calculated vapor risk screening levels (VRSL)
 - Risk of too much PCE entering building from subsoil
 - Responsible Party and WDNR were close to approving and installing a >\$100K vapor mitigation system





- Method
 - Paired sub-slab and indoor air samples were collected by Gannett Fleming at 7 locations throughout facility and analyzed for PCE and Radon during the heating & non-heating seasons
 - Radon concentrations in sub-slab and indoor air were used to calculate slab attenuation factor

Attenuation Factor (AF) - The amount of gas that diffuses through a barrier (e.g. concrete slab)





Questions? Tony Miller awmiller@gfnet.com

- Result
 - Radon AFs were one or more orders of magnitude lower than WDNR's default AF of 0.01
 - The lower actual AFs confirmed that less PCE was entering the building than had been assumed, saving \$100K in unnecessary mitigation system cost







Polling Question #2

Radon for NAPL Studies

- Non Aqueous Phase Liquids NAPLs (e.g. petroleum products) absorb radon
 - Decrease in radon compared to background indicates presence of NAPL
- Two techniques: 1) radon in soil gas for residual NAPL in vadose zone, and 2) radon in water samples for NAPL in the saturated zone
- Radon can be used as a tracer to
 - Map contamination area
 - Quantify contamination
 - Monitor remediation effectiveness







Helmholtz Centre for Environmental Research – UFZ

- Project
 - Determine the contaminated zone of an abandoned airfield in northern Germany. Contaminated zone had previously been investigated by means of soil coring, revealing heavy contamination with diesel fuel. Confirm results by means of a radon survey.





Helmholtz Centre for Environmental Research – UFZ

Materials

- Continuous radon monitor + soil gas probe.

- Method
 - A total of 209 soil gas samples were taken and analyzed directly on site. All samples were taken from a depth of 70 cm to avoid meteorological influences on the soil gas composition.
 - Assume a homogeneous permeability and background radon distribution.



Helmholtz Centre for Environmental Research – UFZ Questions? Michael Schubert michael.schubert@ufz.de

- Result
 - Red dashed area shows contaminated zone as localized previously by soil coring.
 - Lighter shaded zones of radon < 15 kBq/m³ show that the radon survey allowed a more precise localization of the NAPL contamination than traditional soil coring, even though the radon survey was much less costly and timeconsuming.





Polling Question #3

DURRIDGE RAD7

- Continuous radon/thoron monitor for scientific and professional applications
- Accurate. Anywhere.
 - Electrostatic precipitation with alpha spectrometry
 - Sniff mode for rapid response, Normal mode for highest sensitivity
 - With accessories for measuring radon in air, water, or soil

• Easy to use

- Simple user interface & commands
- Intuitive CAPTURE visualization & analytics software









Water Sample Measurements

Soil Gas Probes

Continuous Measurement at the Source



Underground Measurements





- Radon: accurate & cost-effective tracer for environmental remediation studies
- Proven in groundwater/surface water interaction, vapor intrusion, and NAPL contamination cases







Q & A

Carlos Bielicki CEO carlos@durridge.com Dr. Stephen Sadler Chief Scientist stephen@durridge.co.uk



Wrap Up & Thank You

- When you leave the webinar, a link to the course evaluation will appear in your web browser. A link has also been posted in Chat. Please complete the evaluation. Evaluations are required by 309 CMR.
- The LSP CEU certificates will be administered through the LSPA's Learning Management System (LMS). <u>The LSPA will</u> <u>contact you by email once the forms are available to</u> <u>download from the LMS.</u>
- The LSPA's Western MA Committee thanks Carlos Bielicki and Dr. Stephen Sadler of Durridge Co for presenting this webinar.
- The LSPA thanks all attendees for choosing to participate in this professional development opportunity and welcomes your suggestions for future virtual opportunities. Please send comments and suggestions to <u>info@lspa.org</u>