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RADON IN GROUNDWATER

IAEA Webinar

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December 20, 2018

Radon is a radioactive gas that occurs naturally in soil. The gas dissolves into water as it passes through soil.

Exposures from radon in drinking water supply:

Inhale radon gas

- Radon is released into air when water is used.
- Inhalation of radon increases the risk of **lung** cancer.

Drink the water

- Stomach cells could be exposed to increased radiation.

168 cancer deaths/year (USA): 89% lung 11% stomach

National Research Council (US), Committee on Risk Assessment of Exposure to Radon in Drinking Water, 1999.

ICRP has not provided guidance for the control of ingested radon

WHO has not linked radon in water to stomach cancer.



Is my drinking water at risk?

Ground waters contain some radon (4 - 40000 Bq/L)
(may be seasonal variation)

Surface waters contain low levels (<4 Bq/L) of radon

Radon level in water decreases when

- water is agitated (treatment, distribution, usage)
- water is stored (holding tank, reservoir)

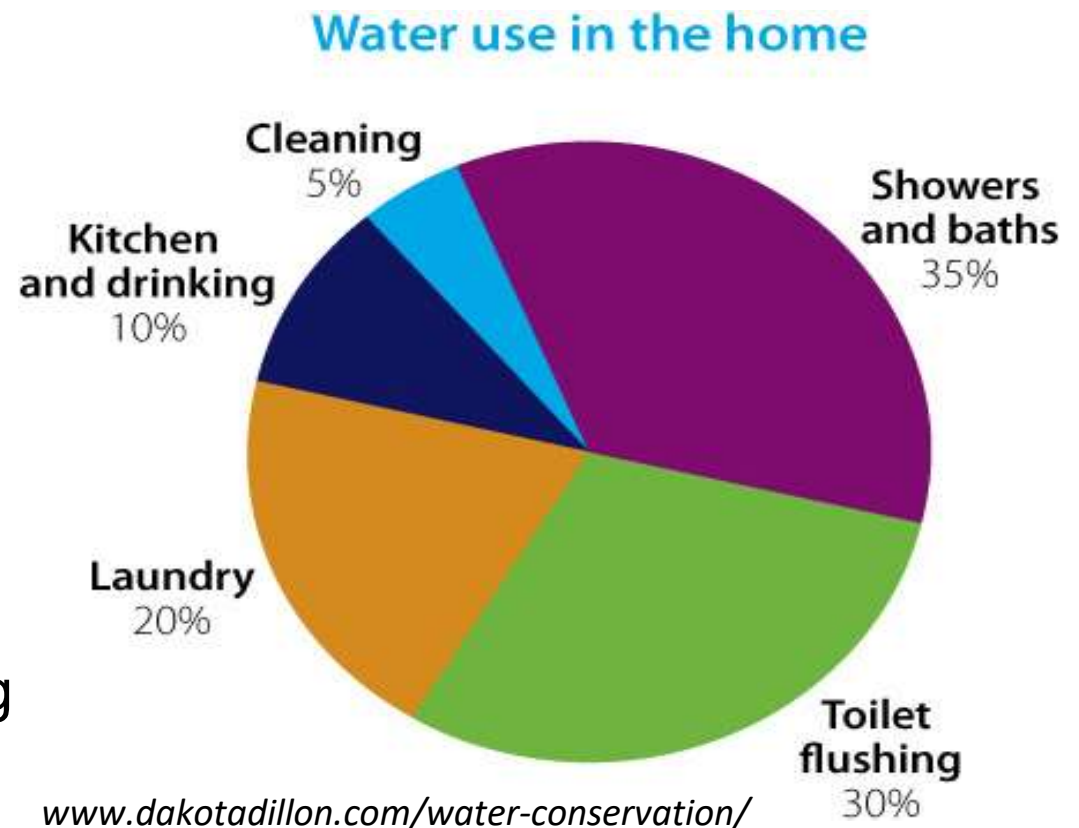


General 1-to-10,000 rule of thumb

Example: 150 Bq/L in water \rightarrow 15 Bq/m³ in air (outdoor level)
(150000 Bq/m³)

Factors affecting contribution from water to air

1. Solubility of radon in water
2. Type of water-use activity
3. Amount of water used in building
4. Volume of building
5. Ventilation rate of building



Transfer Efficiency

Environ. Sci. Technol. 1997, 31, 1822–1829

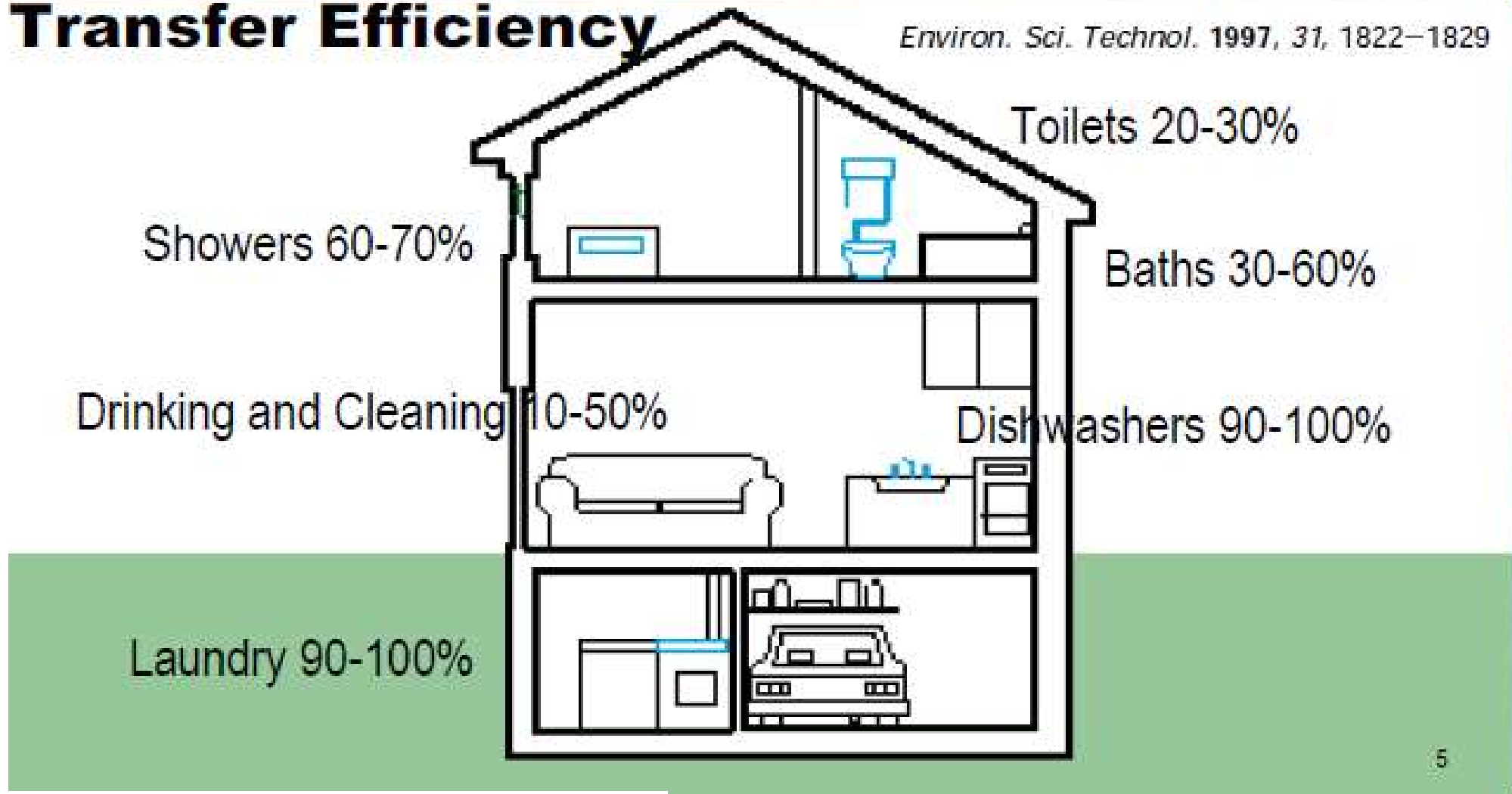
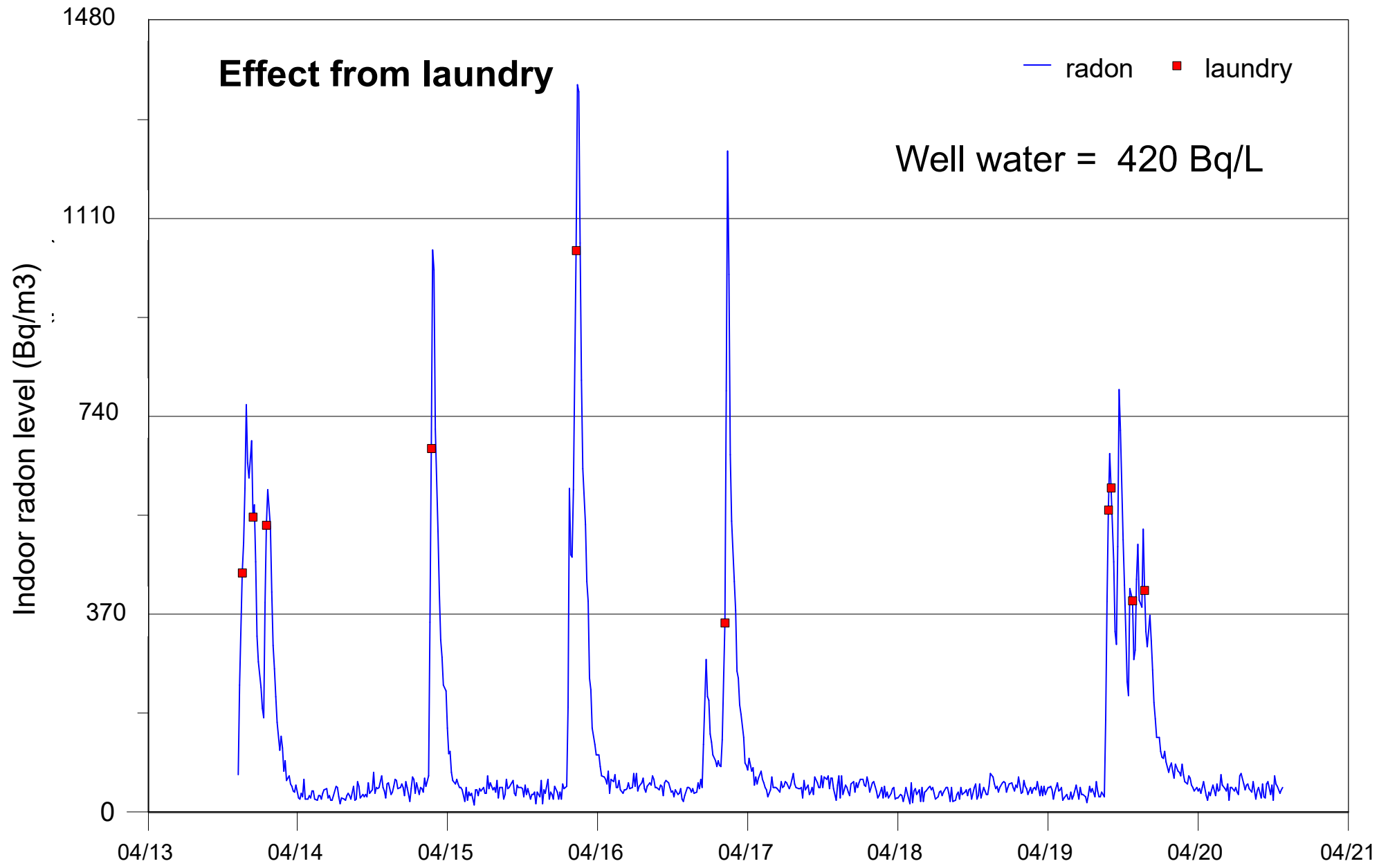


TABLE 1. Laboratory Measured Emanation Fraction

shower head	water temp (°C)	²²² Rn in water concn before shower (kBq m ⁻³)	²²² Rn in water concn after shower (kBq m ⁻³)	emanation ^a (%)
head 1	32	374	108	71
	32	773	233	70
	21	375	124	67
	21	207	58	72
head 2	32	254	69	73

Typical water use :
250-300 liters per person per day



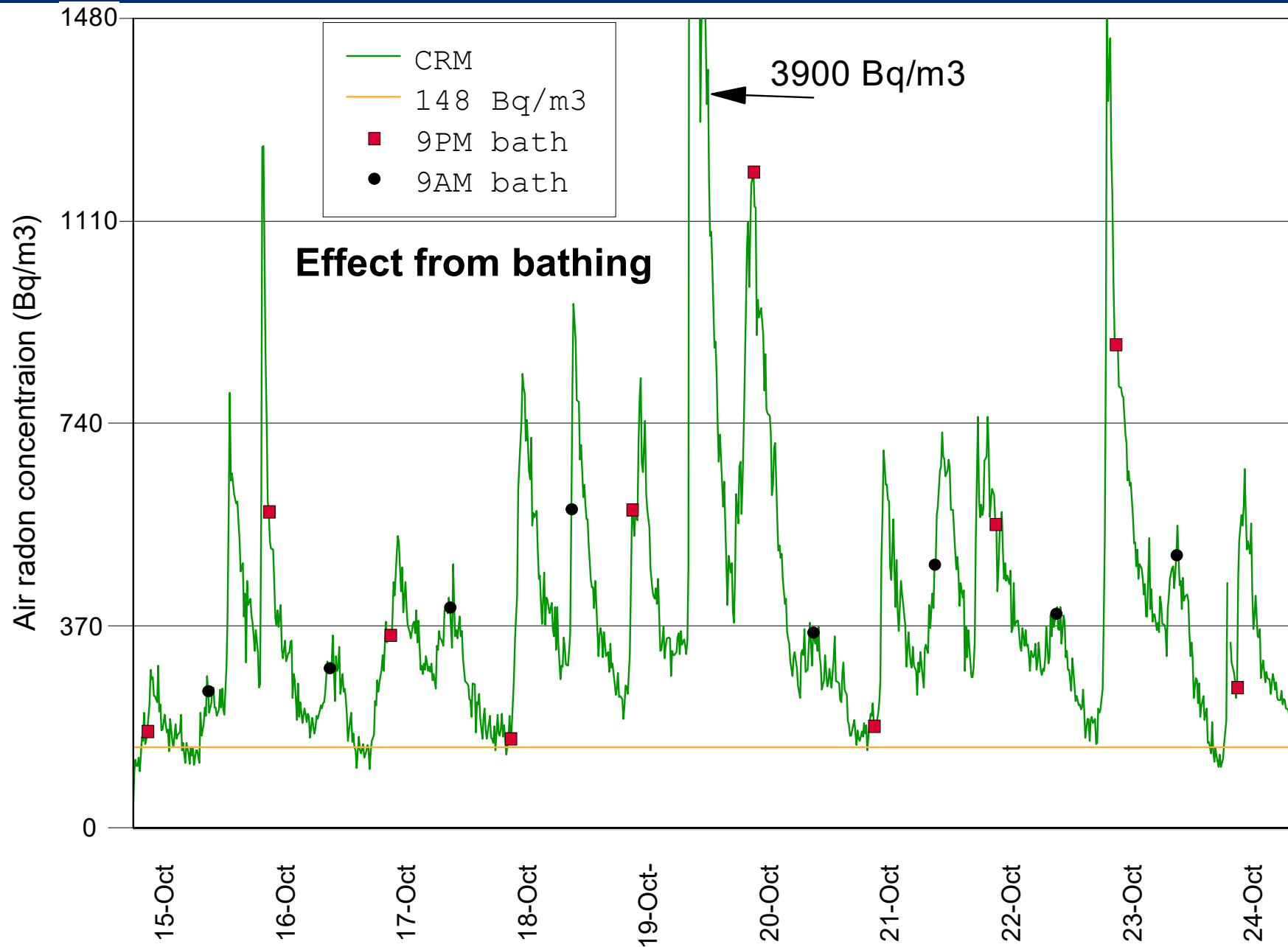


Unpublished data, Michael Kitto



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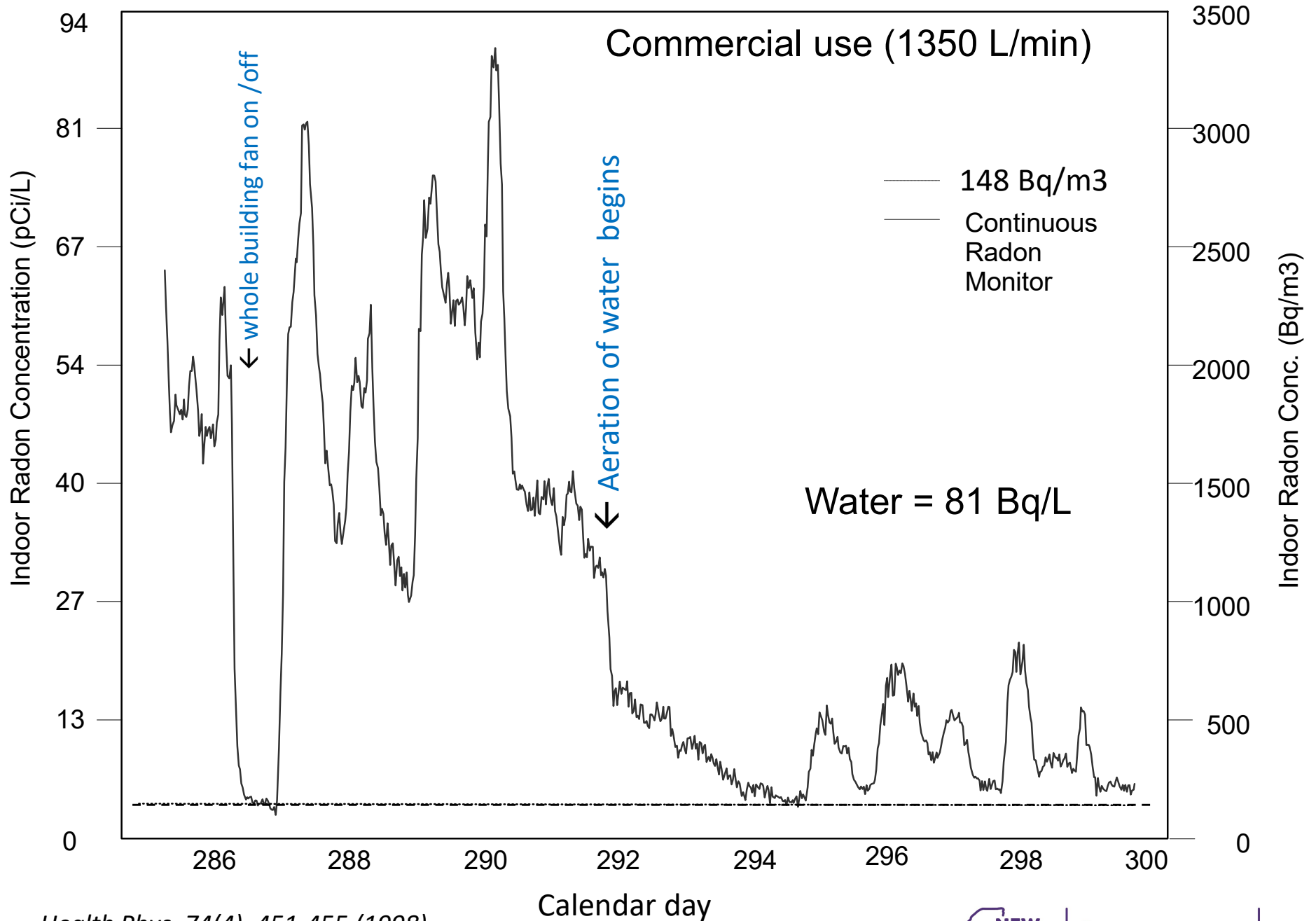


Unpublished data, Michael Kitto



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Health Phys. 74(4), 451-455 (1998)



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Recommendations for sampling of radon in water

Run the water long to get fresh sample

Example: For a “fresh” water sample

- 2.5 cm diameter piping
- 76 m depth to well water
- 14 m of piping through home

dispose of at least 50 liters of water

Remove faucet aerator



Collect prior to treatment or holding tank

Ring cap. Green dot indicates proper liner position.

Aluminum liner

PTFE liner

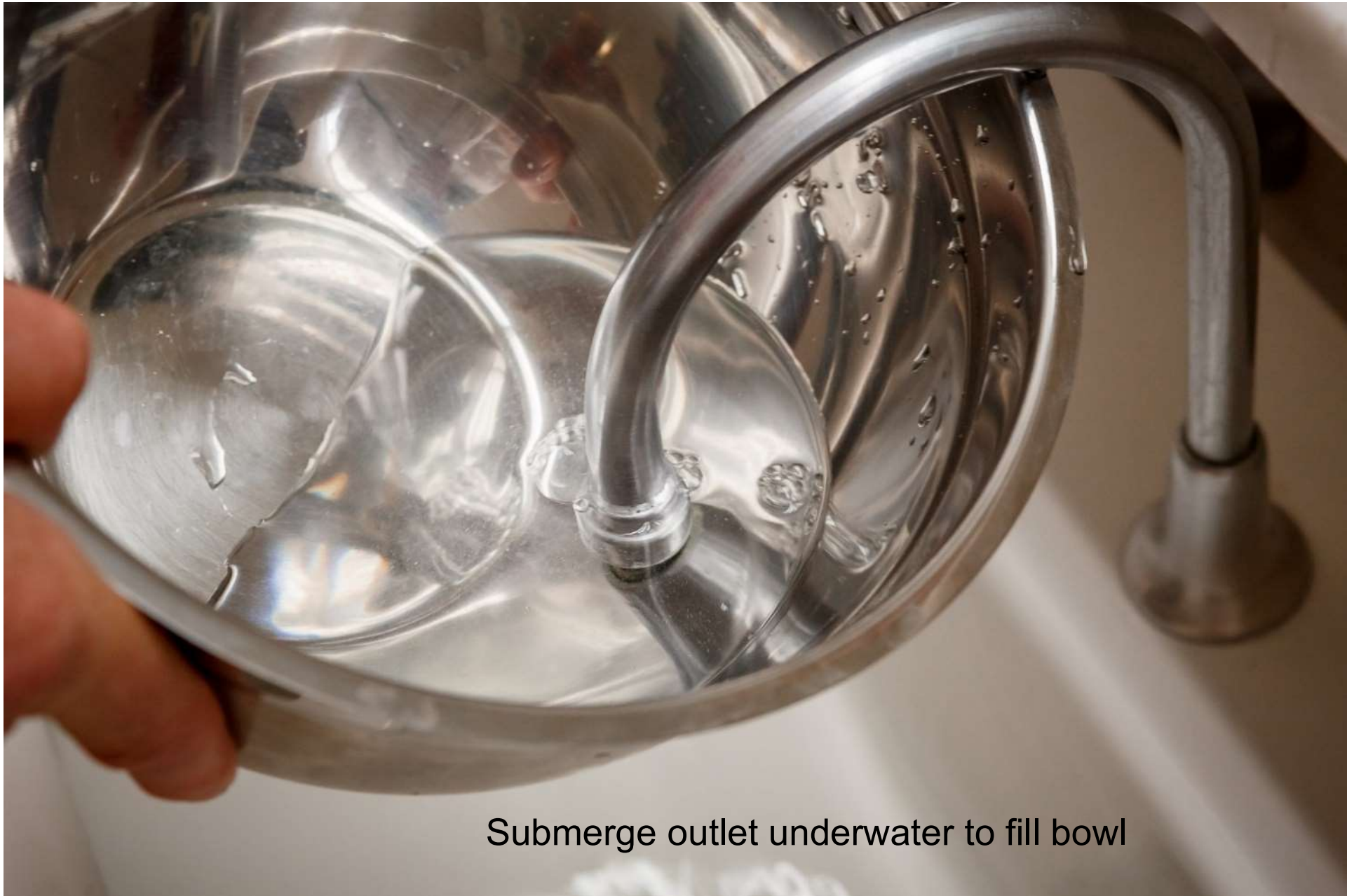


Photo: with permission from Wadsworth Center

Submerged faucet and funnel



Photo: with permission from Wadsworth Center



Submerge outlet underwater to fill bowl

Photo: with permission from Wadsworth Center



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Open bottle underwater



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**Slow flow.
Tubing at bottom of bottle.
Fill bottle and cap.**

Photo: with permission from Wadsworth Center



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Inject water
under
scintillation fluid

Photo: with permission from Wadsworth Center



Fill syringe from bottom of bowl of water



Photo: with permission from Wadsworth Center

Fill syringe from bottom of funnel



Water slowly
overflows
funnel



Slide bottle under faucet is NOT allowed

Photo: with permission from Wadsworth Center



Analytical methods for measurement of radon in water

- Liquid Scintillation counting
- Alpha Scintillation (“Lucas”) cell
- Electret
- Continuous Radon Monitor
- Isotopic Gamma Spectrometry

Laboratories demonstrate measurement proficiency

NOTE : Radon level in water sample does NOT equate to Ra-226 level.

Rn-222 and Ra-226 are not in equilibrium in fresh water sample.



Liquid scintillation counter can measure a series of radon cocktails.



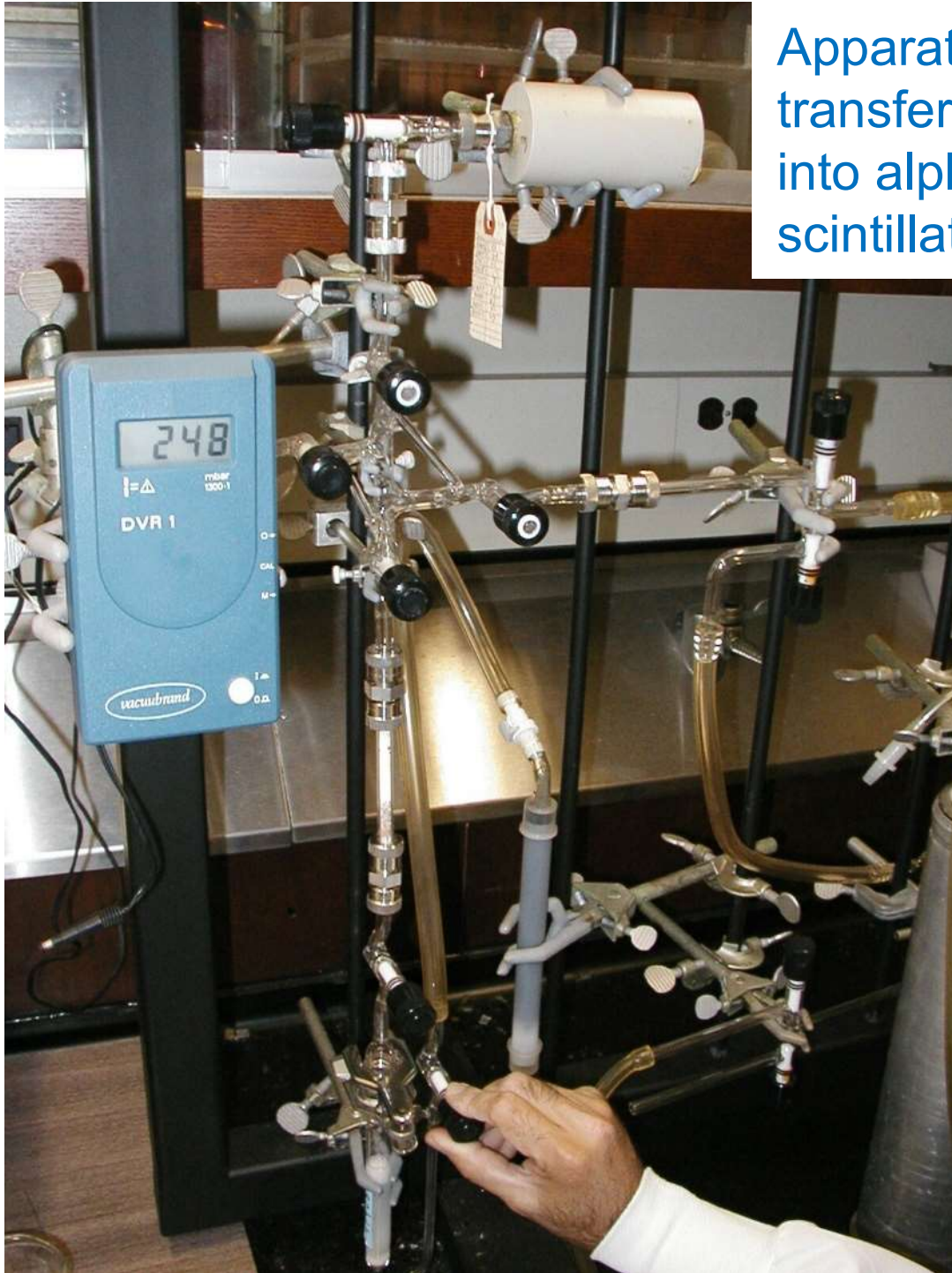
Kitto, et al., J. Radioanal. Nucl. Chem., Articles 185, 91 (1994)



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Photo: with permission from Wadsworth Center



Apparatus to transfer radon into alpha scintillation cell

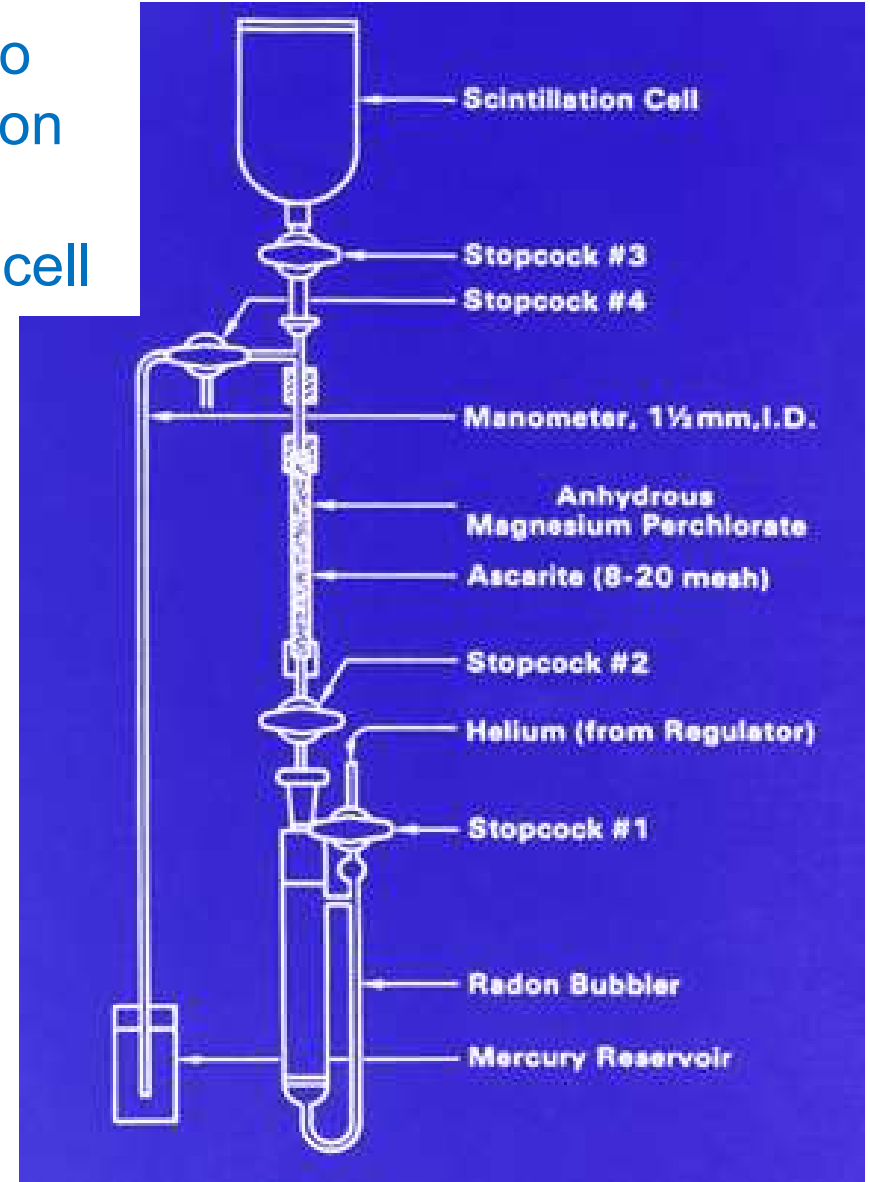


Photo: with permission from Wadsworth Center



Computer controlled counters for alpha scintillation cells



Measurement using electret method
Kitto, *J. Environ. Radioact.* 99, 1255-1257 (2008)



**Continuous
Radon
Monitors**

**with water
attachment**



**Gamma-ray
spectroscopy**



Photo: with permission
from Wadsworth Center

RADON IN WATER INTERCOMPARISONS CONDUCTED BY KITTO

2009 participants:

USA Gov't lab	1
State lab	4
County lab	1
Private company	12
Private individual co.	2
University	3

2010 participants:

15 states and 1 international

CA	NC
CO	NH
CT	NJ
FL	NY
IA	PA
LA	SC
MA	WI
MD	non-USA

2016 study

Bulgaria	1
Canada	1
Finland	1
Estonia	1
France	2
Germany	1
Italy	10
Moldova	1
Montenegro	1
Poland	1
Portugal	2
Serbia	1
Spain	1
Sweden	1
USA	13





Reusable source for radon in water

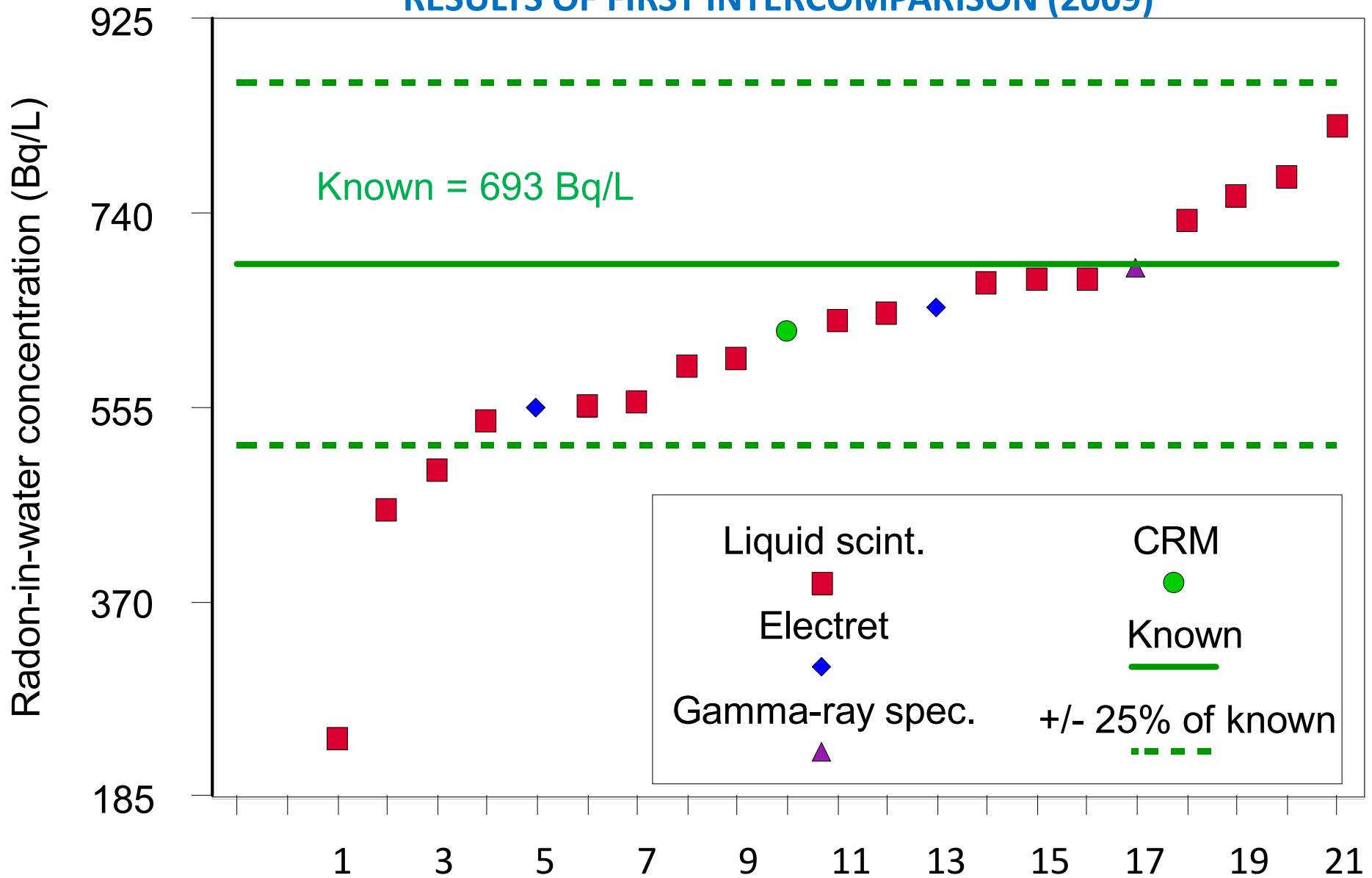
Radiation Measurements 45, 231-233 (2010)



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RESULTS OF FIRST INTERCOMPARISON (2009)



Kitto, Radiation Measurements 45, 231-233 (2010)

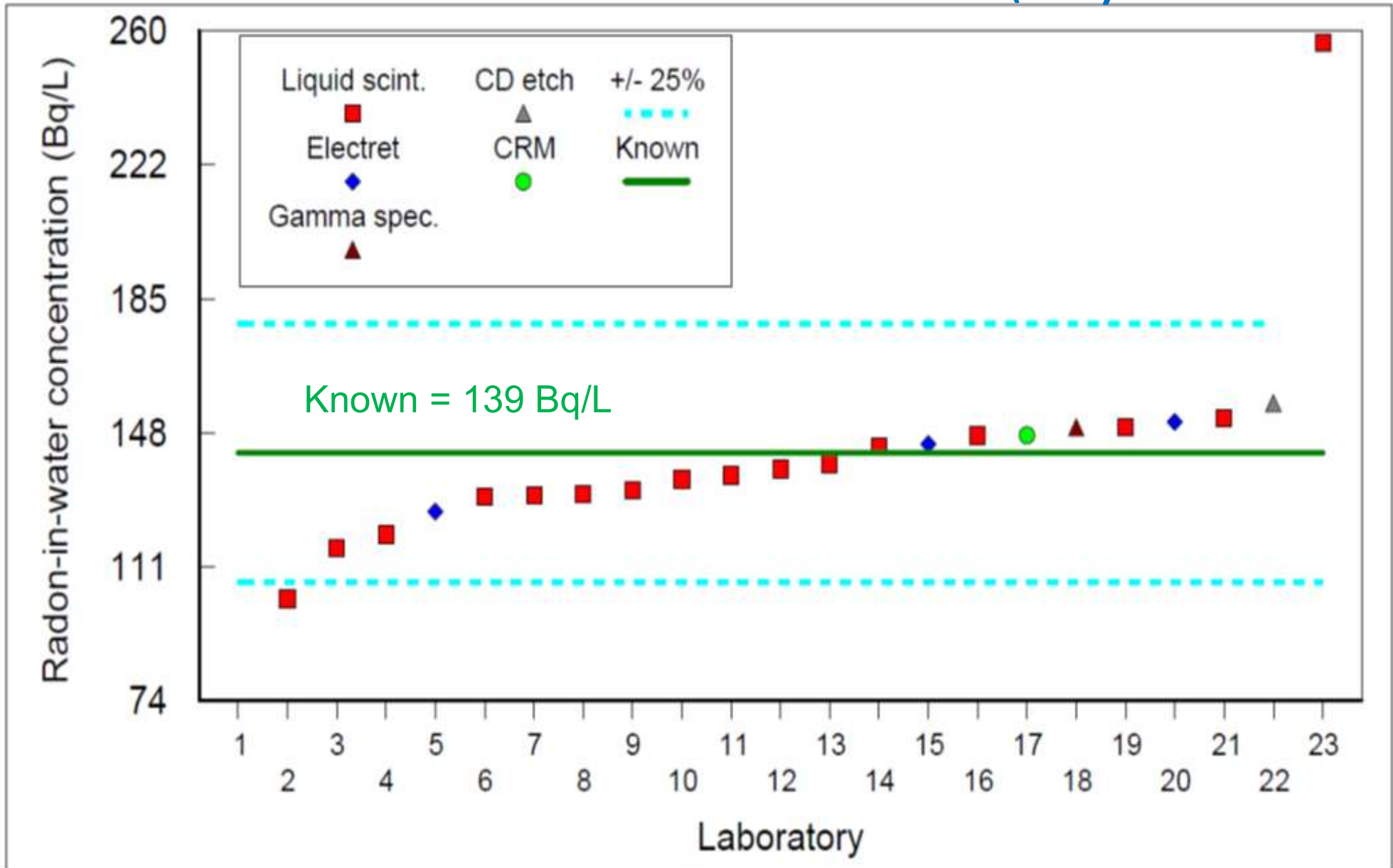
Participant



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RESULTS OF SECOND INTERCOMPARISON (2010)



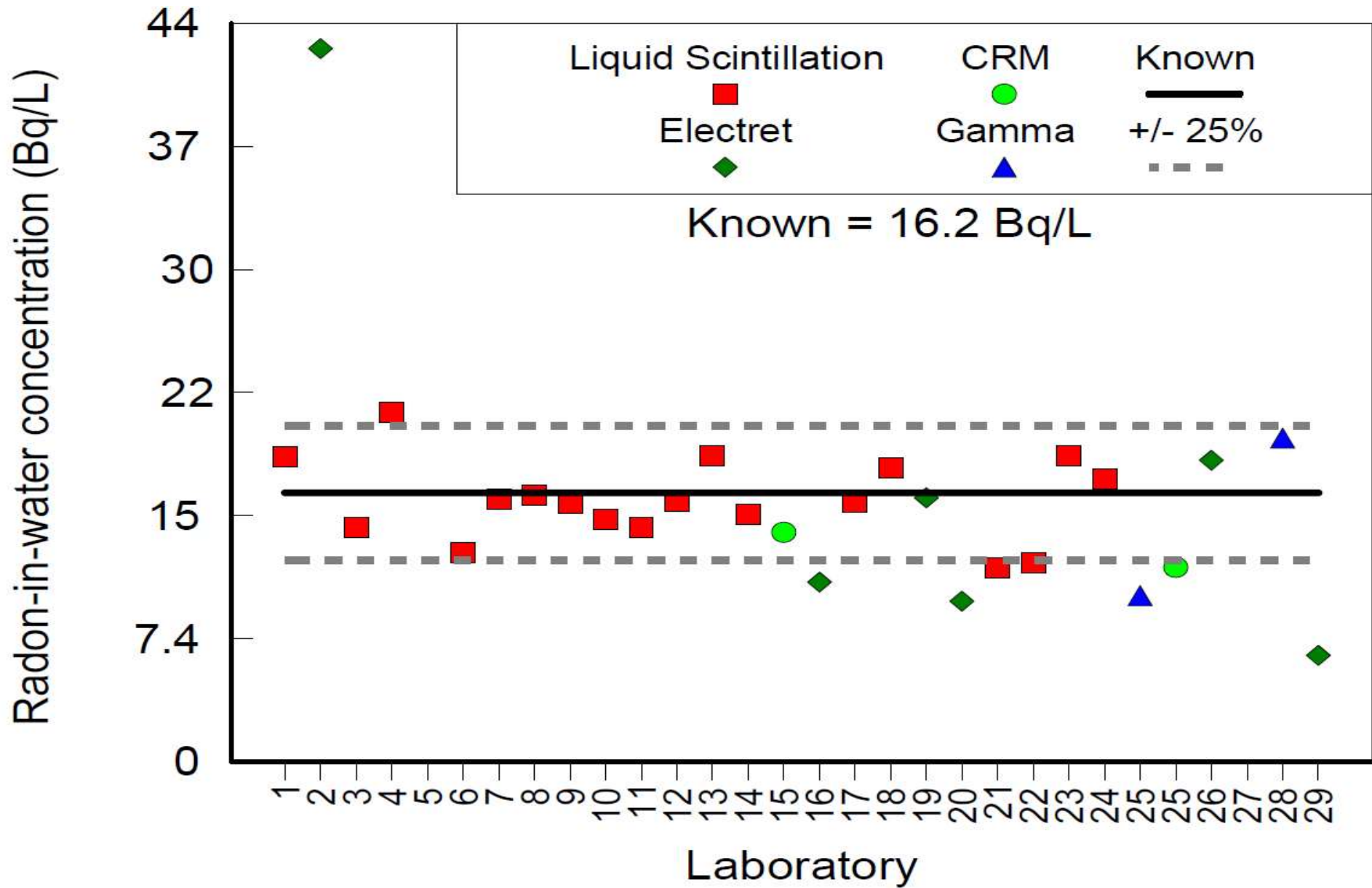
Unpublished data, Michael Kitto



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RESULTS OF THIRD INTERCOMPARISON (2016)



Unpublished data, Michael Kitto



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Reduction of radon in water



- Storage (hold and decay)
- Blending (mix in cleaner water)
- Granular Activated Charcoal (GAC)
- Aeration units



If radon concentration is

below 200 Bq/L → charcoal or aeration

above 200 Bq/L → aeration recommended

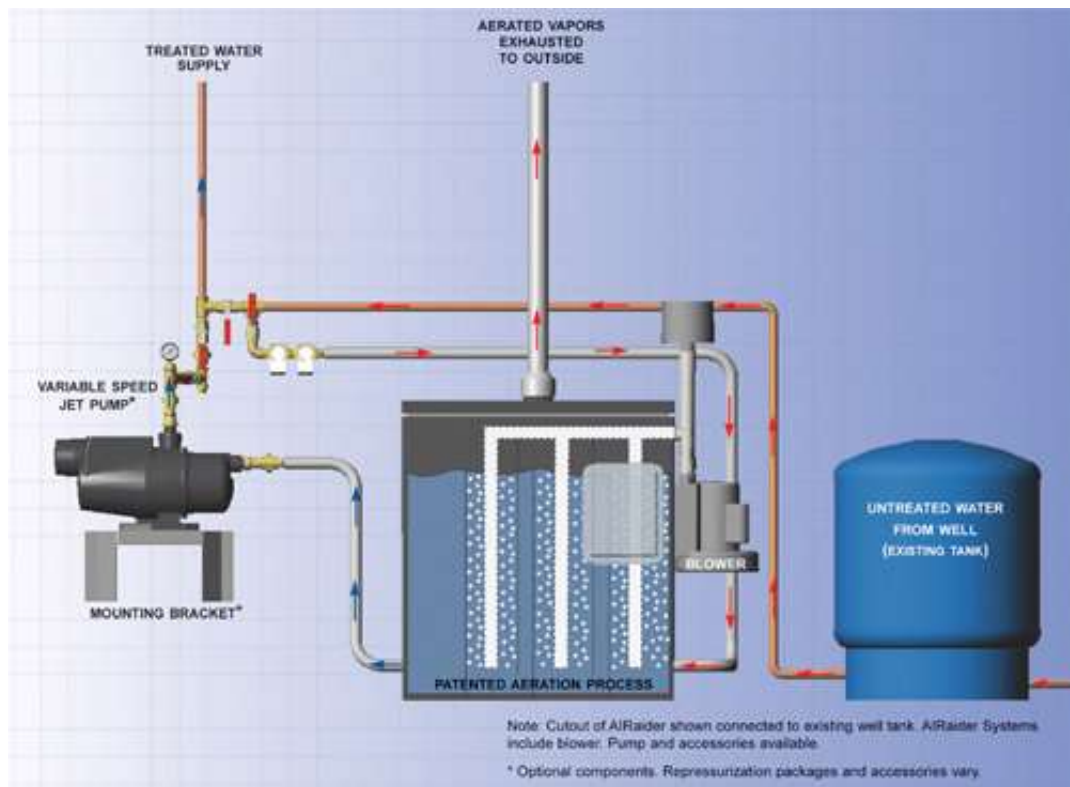


Household Remediation of Radon in Water

Methods are capable of over 95% reduction.

Aeration

- Utilizes natural tendency of radon to diffuse out of water
- Inject smaller bubbles in water to release radon
- Radon released in off-gas (outdoor ventilation is required)



Granular Activated Carbon (GAC) Absorption

- Water passes through GAC which absorbs the radon and other contaminants.
- This system has the disadvantage that radioactivity can build up in the unit. (May require caution tape, warning sign, and special disposal.)



Questions ?



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