# Radon Flux from Evaporation Ponds

Kenneth R. Baker, Ph.D.
Environmental Restoration Group, Inc
Albuquerque, NM

and

Alan D. Cox
Homestake Mining Company of California
Grants, NM

# Current Issue: Regulatory Agencies Expressing Interest in Radon Emissions from Ponds

- Approach to evaluate issue included
  - Modeled radon emissions from pond
  - Studied water vapor adsorption on activated charcoal flux canisters
  - Studied effect of water vapor adsorption on flux measurements
  - Performed Radon Flux Measurements on a pond

# Model

- Stagnant-Film model for the transport of a gas across an air-water interface[1]
  - Results of:

Radon Flux = 0.01 pCi $m^{-2}$ $s^{-1}$ per pCi $L^{-1}$ of dissolved radon

[1]**Summarized in** Schwarzenbach, Rene P., Philip M. Gschwend, and Dieter M. Imboden. *Environmental Organic Chemistry*. 2nd Edition. 2002

# Predicted Flux at Homestake Evaporation Pond (EP-1 )

- Measured Ra-226 concentration = 165 pCi $L^{-1}$
- Measured Temperature = 20.6 $^{o}C$
- Assume Rn-222 in secular equilibrium with Ra-226

Model Predicted Flux at EP-1 = 1.65 pCi $m^{-2}s^{-1}$

# ERG Radon Flux Canister Design

Figure 1. ERG Radon Flux Canister

- Charcoal weight is approximately 385 grams
- EPA design calls for 170 grams of charcoal

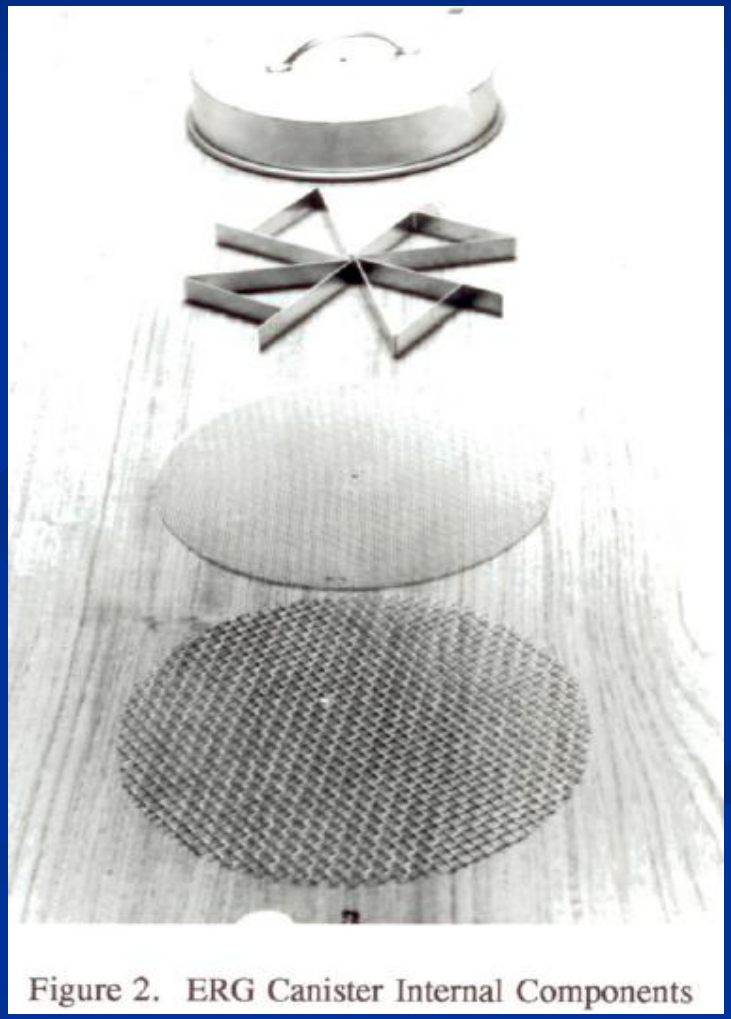

Figure 2. ERG Canister Internal Components

# Flux Canister Floatation Platform

- 10-in. ID plastic pipe
- 4-in. low density foam
- Tape band

# Previous Water Vapor Adsorption Studies

- Affects observed in previous studies
  - **radon adsorption efficiency is reduced as temperatures and humidity increases**
  - **water vapor competes with radon adsorption**
  - **water vapor reduces radon adsorption when water mass gain of charcoal exceeds 11 %**

# Radon Flux Baseline Studies

Configuration: Analyzed 9 Unexposed Canisters

Result: Mean Flux = 0.12 ± 0.11 pCi $m^{-2}s^{-1}$

# Radon Flux Baseline Studies

- Configuration: Analyzed 10 canisters exposed for 24 hours to only water

Result: Mean Flux = 0.13 ± 0.10 pCi $m^{-2}s^{-1}$

# Radon Flux Baseline Studies

- Deployed 23 flux canisters on newly constructed radon barrier in NM (August 2009) following EPA Method 115 procedures :
  - Increase in mass of 5.9 ± 1.0 percent, based on dry weight of charcoal
  - Three canisters placed at background location with results of 1.08, 1.15, and 1.42 pCi $m^{-2}s^{-1}$

# Water Vapor Adsorption Studies with Desiccant

- Inserted 2-cm thick desiccant between canister
- Desiccant became saturated within 6 hours
- Abandoned possible desiccant use

# Water Vapor Adsorption Studies

- Configuration:  Floating Platform on pool of aged-city water
  - Five canisters deployed for 24 hours
  - Uniform temperature of 20-23 $^{o}$C

Result:  Increase in mass ranging from 4.5 to 5.2 percent, based on dry weight of charcoal, with an average of 4.8 percent

# Assessment of Radon Adsorption During Study (24-hour exposure)

| Canisters | Number | Moisture Content (%) | Mean Flux (pCi $m^{-2}s^{-1}$) | Standard Deviation (pCi/$m^{-2}s^{-1}$) |
|---|---|---|---|---|
| After Baking Out | 5 | 0 | 0.10 | 0.10 |
| After Placement On Water | 5 | 0 - 5.2<br><br>4.8 avg | 0.11 | 0.08 |
| After Placement On Flux Pad | 5 | 4.8 avg | 1.76 | 0.06 |

Shows that canisters do not adsorb radon from air while on floating platform

# Influence of Canister Moisture on Flux Measurements

| Canisters | Number | Moisture Content (%) | Mean Flux (pCi $m^{-2}s^{-1}$) | Standard Deviation (pCi $m^{-2}s^{-1}$) |
|---|---|---|---|---|
| Exposed to Flux Pad Only | 7 | ≈ 0 | 1.84 | 0.34 |
| Exposed to Water before Flux Pad | 8 | 7.1 -8.8 Avg 7.9 | 2.10 | 0.16 |

# Flux Measurements on EP-1 Homestake Uranium Mill Site

| Canister Number | Flux ($pCi\ m^{-2}s^{-1}$) | Flux Standard Deviation ($pCi\ m^{-2}s^{-1}$) | Percent Moisture Increase |
|---|---|---|---|
| 43 | 1.77 | 0.06 | 11.06 |
| 12 | 1.12 | 0.05 | 10.57 |
| 82 | .99 | 0.05 | 13.38 |
| 44 | 1.02 | 0.05 | 10.68 |
| 13 | 0.77 | 0.05 | 9.38 |
| Mean | 1.13 | | 11.0 |

# Summary

- Canisters adsorb little radon from air while on water
- Measured radon flux was not affected by charcoal moisture content under measurement conditions
- Model predicted 1.65 pCi/m$^2$s which compares well with the mean measured flux of 1.13 pCi/m$^2$s

Questions?