Determination of Radon Adsorption to Atmospheric Aerosols by Disequilibria of its Progeny

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Background: Aerosols

- Defined as any suspended particle or colloid in the size range of ~.002 to 10 µm in effective diameter
- Because of this broad definition, aerosols have diverse compositions, thus broad climate effects
  - We’ve heard stories from Torreon, Mackenzie, Adele, Mikey, and soon…Shallena
- One important question: How long do they stay suspended in the atmosphere?
Background: Radionuclear Tracers

The $^{238}$U decay series
Tropospheric Tagging
The Pool Analogy

$^{222}\text{Rn}$

- 3.8 days

$^{214}\text{Pb}$

- 26.8 min

$^{214}\text{Bi}$

- 19.7 min

$^{210}\text{Pb}$
Aerosol Age-dating

• By measuring the radionuclear activities and taking the ratio between them, atmospheric lifetimes can be derived

\[
\frac{^{210}\text{Po}}{^{210}\text{Pb}} = \frac{T_R^2}{(T_R + 1/\lambda_{\text{Bi}})(T_R + 1/\lambda_{\text{Po}})}
\]
\[
\frac{^{210}\text{Bi}}{^{210}\text{Pb}} = \frac{T_R}{(T_R + 1/\lambda_{\text{Bi}})}
\]

• Where \( \lambda \) is an element’s decay constant

Solving for \( T_R \) gives an approximated residence time for the given radionuclide
Radon: Our Parade

- However, these ratios can be distorted by concurrent decay and growth of a specific nuclide

- Remember the pools

- If Radon is filling the pools of Bismuth and Polonium, their decay will be affected
• Radon Gas, with its known affinity for oils, can adsorb on to the surface of aerosols with more “oily” surfaces.

Total C ∝ Rn adsorption ?
$^{222}\text{Rn}$

$^{214}\text{Pb}$

$^{214}\text{Bi}$

$^{210}\text{Pb}$

3.8 days

26.8 min

19.7 min
Experimental

• To address the radon adsorption question

• 11 samples taken by impaction
  – Sample times ranged from 3-150 hours

• Filters gamma-counted immediately to track decay of short-lived $^{214}\text{Pb}$ and $^{214}\text{Bi}$
Surface Area Distribution of Aerosols
Impactors
Impactor Theory

> 1 µm

1 µm > .1 µm

Plates

Filter
Gamma Counting

Using a
Canberra
DSA 1000
Broad Energy
Gamma Ray
Spectrometer
Results

Decay of Pb 214 vs $t$

Time from 0 (s)
Actual Decay of Pb214 vs Average Calculated Decay of Pb214 vs Average Decay Rn 2
Preliminary Conclusions

• Work in progress, bear in mind

• Data strongly suggests radon adsorption
  – Lead appears to approach transient equilibrium with Radon

• Potential Connection between sample time and radon adsorption
Current/Future Work

• Chemical extraction of $^{210}$Pb from $^{210}$Po and $^{210}$Bi
  – Hopefully to gain further evidence on “excess” polonium problem
    • Or is it the “excess” alpha problem?

• Simultaneous Radon Counting

• In-line combustion system for Total Carbon determination
Beta Counting

Extraction
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