Air Dosimetry Report

Ionizing Activity of Radon Daughter Isotopes

This report is intended to inform you of the "background radiation" in the vicinity of Kearney Nebraska.

Just as drinking water may reasonably contain radiological contaminants, dust carried in the air also contains natural radiological materials. The *Annual Water Quality Report* provided by the City of Kearney reports these values in picoCuries per liter. This report lists airborne radiological contaminants in picoCuries per cubic meter and compares the measured activity to the EPA's benchmark for Radon in your home.

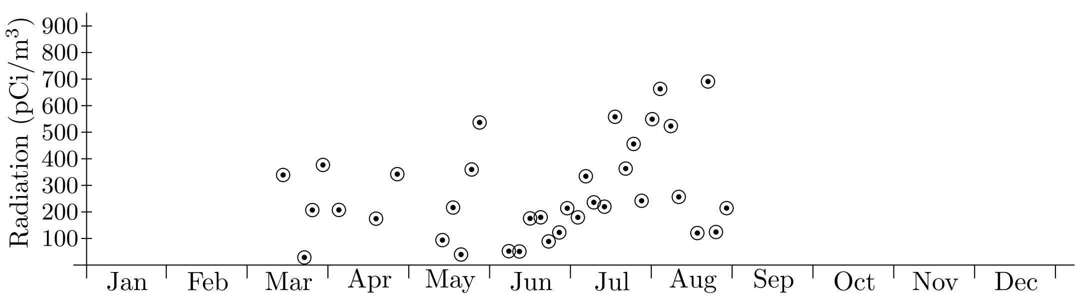
We captured dust from 25 Aug 2014 to 29 Aug 2014 ($t_{\text{stop}} \sim 94.4$ hr) in the EPA RadNet monitoring station located atop UNK's Bruner Hall of Science. Analysis shows that during that time dust particles carrying two types of radiation emitters produced exposure in the following amounts:

$$\alpha \text{ - exposure} \approx 33.20 \text{ pCi/m}^3$$
$$\beta \text{ - exposure} \approx 181.10 \text{ pCi/m}^3$$

The overall exposure rate for this time span was 214.2969 pCi/m^3.
Comparing this sample to the EPA standards, the measured exposure was about 5.4% of the EPA's benchmark for Radon in your home. The EPA recommends remediation if tests show your home contains 4000 pCi/m^3 or more.

If you approximate your respiration rate to be $12 \rightarrow 20$ breaths per minute, and your tidal volume (the amount of air you inhale each breath) to be about 0.0005 m^3/breath, then the results quoted in this report suggest an exposure in the range of $(0.6750 \rightarrow 1.1251)\mu$Ci/yr.

The chart below places this most recent value in context with previous results:



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Station #: 724 Kearney, NE
Sampled Days : 2014 08 25 → 2014 08 29

RadNet Air Monitoring

RadNet has more than 100 stationary (fixed) radiation air monitors in 48 states. ... RadNet runs 24 hours a day, 7 days a week, and sends near-real-time measurements of beta and gamma radiation to EPA's National Air and Radiation Environmental Laboratory (NAREL). ... Filters on the air monitors capture particles from the air (airborne particulates). Monitor operators collect the filters and send them to NAREL for testing that double-checks the monitor readings. Staff use these test results to calculate the concentration of radionuclides on the particles and find trends in airborne radiation.

The filters from each monitor are sent to EPA's NAREL, where they are analyzed for gross beta radiation. If beta activity in the sample exceeds one picocurie per cubic meter (1 pCi/m^3), the lab conducts a follow-up scan for gamma activity.

Background Radiation:

> The ubiquitous ionizing radiation we are exposed to from natural as well as artificial sources in our environment is called background radiation.

Quotation from: http://www.epa.gov/enviro/facts/radnet/

> RadNet data provides a means to estimate levels of radioactivity in the environment, including background radiation as well as radioactive fallout from atomic weapons testing, nuclear accidents, and other intrusions of radioactive materials. RadNet also provides the historical data needed to estimate long-term trends in environmental radiation levels.

Local (volunteer) monitor operators operate these EPA RadNet monitoring stations with a standardized protocol as per *NAREL Standard Operating Procedure for Using the Ludlum Alpha/Beta System for Counting RadNet Air Filters* section 6.4 Counting Air Filters: NOTE: Filters should not be counted until at least five hours after removal from the air sampler, to allow time for decay of interfering radon daughter isotopes.

For More Information: www.epa.gov/radnet/index.html

UNK's Auxiliary Protocol

This report is the result of a protocol developed at UNK to measure the activity of the interfering radon daughter isotopes highlighted in section 6.4 of the NAREL defined protocol. With this we develop a near real-time exposure history to short lived isotopes carried by airborne dust in our local area. As the air sampler is switched off the radiation load on the filter begins to diminish exponentially.

$$\mathcal{A} = \mathcal{A}_1 e^{-\lambda_1 t} + \mathcal{A}_2 e^{-\lambda_2 t}$$

Measuring the "decay" curves for the Alpha and Beta emitters we determine the accumulated activity for each at the moment the sampler was turned off ($t = t_{\text{stop}}$). We then estimate the accumulation rate ($\mathcal{R}$) for each type of ionizing radiation (α and β) trapped in the filter as the sampler ran for 3 or 4 days ($\approx$ 72 hr or $\approx$ 94 hr).

$$\mathcal{R} = \left\{ \frac{\lambda_1 \mathcal{A}_1}{(1 - e^{-\lambda_1 t})} + \frac{\lambda_2 \mathcal{A}_2}{(1 - e^{-\lambda_2 t})} \right\} \Bigg|_{t=t_{\text{stop}}}$$

While the rate of deposition is most likely <u>not constant</u>, we can estimate the <u>average rate of deposition</u> over the last several hours of sampling time, and use it to determine the reported radiation concentration.

Data on the next two pages illustrate how the reported result is calculated.

α Data

Table 1: Alpha Activity

Time (hr)	Count Rate (pCi)
0.13333	1635.4
0.31667	1224
0.48333	1105
0.73333	918
0.98333	708.9
1.33333	504.9
2.4	243.1
3.08333	212.5
4.4	173.4
6.05	113.9

The best fit to the data suggests two time constants for the Alpha particle emitters with their associated activities at the moment the sampler was shutdown.

$\mathcal{A}_1 = 1586.6$ pCi $\quad \lambda_1 = 1.2369\ \text{hr}^{-1} \quad \mathcal{A}_2 = 248.32$ pCi $\quad \lambda_2 = 0.1178\ \text{hr}^{-1}$

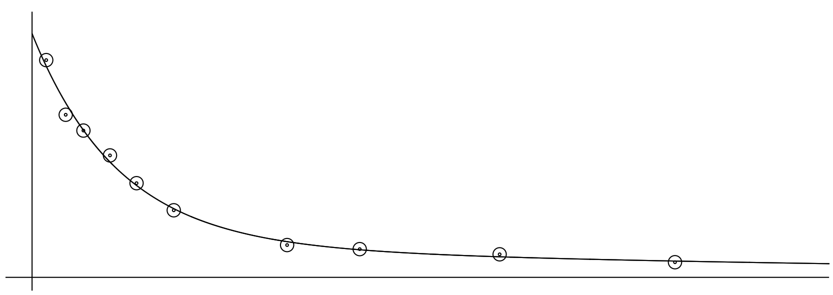

Figure 1: α Activity versus Time

This sketch[1] exists only to provide a visual representation of the phenomenological fit to the data.

α emitting radon daughter isotopes arrived at the filter with an average rate given by:

$$\mathcal{R} = \frac{\lambda \mathcal{A}_{\text{stop}}}{(1 - e^{-\lambda t_{\text{stop}}})} \Rightarrow \mathcal{R}_1 = 1962.4655\ \frac{\text{pCi}}{\text{hr}} @\ \tau_1 = 0.81\ \text{hr}\ ,\ \text{and}\ ,\ \mathcal{R}_2 = 29.2525\ \frac{\text{pCi}}{\text{hr}} @\ \tau_2 = 8.49\ \text{hr}$$

$\mathcal{R} \times 94.383333\ \text{hr}/5662.2\ \text{m}^3 \approx 32.7124\ \text{pCi/m}^3$, and , $0.4876\ \text{pCi/m}^3$.

[1] The axes have neither scales nor units.

β Data

Table 2: Beta Activity

Time (hr)	Count Rate (pCi)
0.13333	8774.48
0.31667	7379.72
0.48333	6490
0.73333	4704.66
0.98333	3888.1
1.33333	2788.34
2.4	1451.4
3.08333	1177.64
4.4	948.72
6.05	867.3

The best fit to the data suggests two time constants for the Beta particle emitters with their associated activities at the moment the sampler was shutdown.

$\mathcal{A}_1 = 9233.8$ pCi $\quad \lambda_1 = 1.1743$ hr^{-1} $\quad \mathcal{A}_2 = 873.95$ pCi $\quad \lambda_2 = 0.020628$ hr^{-1}

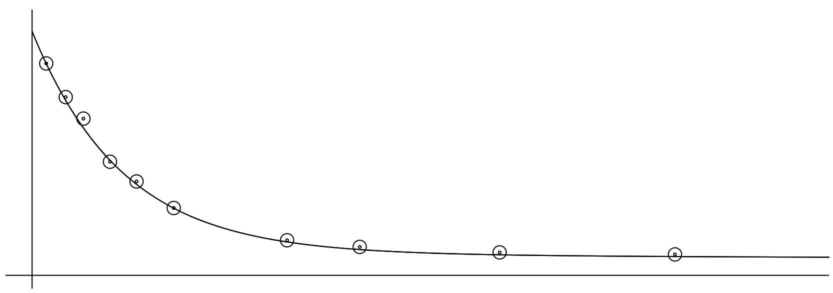

Figure 2: β Activity versus Time

This sketch[2] exists only to provide a visual representation of the phenomenological fit to the data.

β emitting radon daughter isotopes arrived at the filter with an average rate given by:

$$\mathcal{R} = \frac{\lambda \mathcal{A}_{\text{stop}}}{(1 - e^{-\lambda t_{\text{stop}}})} \Rightarrow \mathcal{R}_1 = 10843.2513 \, \frac{\text{pCi}}{\text{hr}} @ \, \tau_1 = 0.85 \text{ hr} \text{ , and , } \mathcal{R}_2 = 21.0289 \, \frac{\text{pCi}}{\text{hr}} @ \, \tau_2 = 48.48 \text{ hr}$$

$\mathcal{R} \times 94.383333$ hr/5662.2 m$^3 \approx 180.7464$ pCi/m^3, and , 0.3505 pCi/m^3.

[2] The axes have neither scales nor units.