Ancillary Protocol: RadNet Air Monitoring System

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(Dated: 5 November 2015)

Extracting more information than the Environmental Protection Agency intended.

The University of Nebraska at Kearney RadNet study group developed an ancillary protocol to monitor the activity of short-lived isotopes carried by airborne dust. The EPA protocol specifically ignores this major component of our exposure to environmental radiation.

I. STANDARD OPERATING PROCEDURE

In 1956, the United States Environmental Protection Agency created the Radiation Alert Network which in 2005 became The RadNet Monitoring Network. By early 2015 the network grew to more than 130 stations, each equipped with:

- Rooftop Air Monitoring Station (AMS): essentially a flow regulated vacuum forcing air through an air filter, with a pair of detectors monitoring the filter.
- Laboratory Field Screening Equipment (LFSE): an alpha/beta scintillation detector with scaler, a calibration sample, and sample holders.

A. Pedestrian Procedure

Systemwide, RadNet station operators are volunteers. The EPA's SOP document contains explicit instructions requiring little technical skill on the part of the operators.

The RadNet station volunteer operator:

1. Halts the AMS collection routine.
2. Records AMS's computer information.
3. Replaces the dirty filter with a fresh filter.
4. Restarts the AMS collection program.
5. Places the dirty filter in a LFSE sample holder for at least five hours.
6. Collects four radiation readings using the LFSE.
7. Records the readings, performs a few calculations, and fills in the blanks on a standardized form.
8. Packages the completed standardized form, and dirty filter in a pre-labeled envelope, and sends it to the EPA for analyses.

B. Modification Motivation

The EPA's protocol, by design, ignores short-lived isotopes. However, short-lived isotopes have, by definition, large specific activity compared to that of long-lived isotopes. From a health physics point of view, the effects of short lived isotopes in the environment are of major concern. This concern is more than enough to warrant the development of this ancillary protocol.

II. DESIGN PHASE

Preliminary calculations, eq(3) below, suggest short-lived β-activity consistent with an accumulation rate in the range of a few hundred to a few thousand pCi/m^3. For comparison the EPA Radon standards recommend remediation if tests show your home contains short-lived radioactivity of 4000 pCi/m^3 or more.

There are three primary matters of interest for developing the Ancillary RadNet Protocol.

A. First Do No Harm

Any modifications could not interfere, even marginally, with the EPA's expected operation of the station.

We made no attempt to automate data acquisition as that would require we modify the LFSE. As a result of acquiring data manually, a rather small number of data points could be recorded during the five hour window of opportunity afforded by the EPA's SOP document.

B. Be faithful to the Data

Fitting a single exponential to the data consistently produced poor results. Fitting with a linear combination of two exponentials produced a reasonable fit to the data. The two exponential fit worked very well for approximately 84% of the decay curves in this study. Many of the remaining 16% would not be described as "publishable" by our more discriminating members. Any suggestion that the "Proof of Concept" data supports anything more than "a strong case for further study" would border on hubris at best and fraud at worst. I refer to the results as "Dosimetry Reports" because, any statistical analysis of the decay curves would produce results of little value, as such would imply a level of confidence this experimentalist could not justify. See section III for more on this point.

C. Hot Samples

During the three year design phase, monitoring occurred shortly after removing samples from the AMS. A few times our team encountered a very hot sample. As this occurred before "Ancillary Protocol for EPA's RadNet Standard Operating Procedure" was finalized, no reliable data is available to document these hot samples.

If activity is too great the detector circuitry is unable to process data quickly enough and dead-time issues render measurements unreliable. We opted to record these data points but not to use them in the curve fitting routine.

The EPA's standard pre-screening protocol step(5) is designed to insure short-lived isotopes not interfere with baseline measurements. One of the calculations, step(7), and eq(2) below, is to insure the sample's β concentration does not exceed 1.00 pCi/m^3.

For β concentrations greater that 1.00 pCi/m^3, the EPA SOP is to implement an expedited procedure for shipping the sample.

D. Defining the Ancillary Protocol

The document "Ancillary Protocol for EPA's RadNet Standard Operating Procedure" and other supporting materials are available via:

www.RipPhysics.com/EPA_RadNet/

The protocol involves the addition of two relatively straight-forward processes.

First: Collect activity measurements during the five hours after removing the filter from the AMS. Employ a standard curve fitting routine to determine A_0 (the "halt time" activity), and lifetime (τ). The mathematics for this is relatively straight forward: As the AMS collection routine halts, the amount of activity (characterized by its lifetime, τ) begins to decrease exponentially with time(t) measured from that moment.

$$A \equiv -\frac{dN}{dt} = \left(\frac{1}{\tau}\right) N \implies A = A_0 e^{-t/\tau} \qquad (1)$$

As mentioned above the data supports a fit to a linear combination of two exponentials.

Second: Using a straight-forward process, determine (consistent with λ, and A_0) a reasonable airborne concentration responsible for the accumulated radiation.

1. *Dosimetry: Long-Lived Isotope*

As stated, the EPA standard procedure emphasizes long-lived radioactivity. Operators calculate concentrations using eq(2), obtained as the limit of eq(3) for small values of λt.

$$\mathcal{C} = \frac{A_0}{V} \iff \mathcal{R} = \frac{A_0}{V} \times \frac{V}{t} \qquad (2)$$

In addition this calculation implies a constant rate of deposition ($\mathcal{R}$) where t is the sample collection time.

2. *Dosimetry: Short-Lived Isotope*

We, however, calculate deposition rates appropriate to small values of τ. As the AMS collection routine runs, a deposition rate for short-lived isotopes is given by eq(3), where $\lambda \equiv 1/\tau$:

$$\frac{dA(t)}{dt} = \mathcal{R} - \lambda A(t) \implies \mathcal{R} = \frac{\lambda A_0}{1 - e^{-\lambda t}} \qquad (3)$$

The calculated rates in this study are conservative, as any schedule other than a constant deposition rate produces a larger value of $\mathcal{R}$.

III. PROOF OF CONCEPT

The proof of concept is the collection of Dosimetry Reports dated 15 March 2014 through 1 June 2015.

This study generated one hundred three β activity measurements. Cross-referencing the on-site Field Screening data set with the EPA Gross β in air data set provided eighty coincident pairs of measurements. The two data sets have a weak correlation R = 0.44492. Removing two outliers from each of the two data sets exacerbated the disconnect between these two data sets as R dropped to 0.23205. Measuring the concentration of long-lived (short-lived) radioisotopes does not predict the concentration of short-lived (long-lived) radioisotopes in the environment. The two data sets are not, in any meaningful way, correlated. This observation is graphically illustrates in supplemental documentation available online at www.RipPhysics.com/EPA_RadNet/.

This lack of correlation is important as the EPA protocol specifically ignores short-lived in favor of reporting long-lived radioactivity.

IV. DISCUSSION

Ignoring short-lived isotopes is understandable given the conventional mantra: **Time, Distance, and Shielding**.

However, the RadNet filters collect samples of the dust we breath daily, so the distance, and shielding notions are not applicable. The notion that waiting 5 half-lives allowing a sample to disappear is only meaningful if the radiation is not being continuously replenished.

Not characterizing the short-lived activity directly contradicts EPA's mission objective (referenced below) and is particularly troubling given that the EPA posts online "Gross beta in air (pCi/m^3)" values correlated with the filters sent in from the field.

EPA reports Gross β values from 0.0028 pCi/m^3 to 0.00237 pCi/m^3 (Mean = $(8.9 \pm 3.6) \times 10^{-3}$pCi/m^3).

On-site screening produces values from 12.74 pCi/m^3 to 1441.16 pCi/m^3 (Mean = 267.9 ± 214.2 pCi/m^3).

On-site pre-screening measurements average thirty thousand times the values reported on the EPA's RadNet website.

In addition, the on-site screening routine also allowed us to document the airborne α activity as ranging between 75 and 515 pCi/m^3. Typically, the α concentration is about 10% of the β concentration.

Taken together the combined $\alpha-\beta$ activity was usually measured as about 10% of the EPA's home remediation trigger value of 4000 pCi/m^3.

V. IMPLEMENTATION PHASE

This section is in the subjunctive because as of 20 July 2015 the director of the National Analytical Radiation Environmental Laboratory suspended the field screening measurements for the RadNet Air Monitoring System. The goal of this project (now) is to influence the EPA to reconsider this decision. The EPA should recommit to the original (1956) Radiation Alert Network (RAN) objective, and strive to enhance its present mission objective:

> "To monitor environmental radioactivity in the United States in order to provide high quality data for assessing public exposure and environmental impacts resulting from nuclear emergencies and to provide baseline data during routine conditions."

This technique described in this article for assessing the presence of short lived radioisotopes is not particularly new[1]. Automating the data acquisition process would make it possible to not only collect a statistically significant amount of data for each sample, and circumvent the difficulties referred to in § II B, but to still uses volunteers as station operators.

> "I just don't see how you can avoid the need to obtain high resolution gamma spectra of the samples to see what's really going on."
>
> — Anonymous Reviewer —

Other modifications could enhance the RadNet system in unexpected directions.

VI. ACKNOWLEDGMENTS

This paper exists thanks to: Jeffery Brittenham, Nathan Brady, Adrián Sanabría-Diaz, Kayla M^{c}Mahon, and Joshua Moravec. Without their individual and collective initiative and inspiration this article would not exist.

The spring of 2010 I reluctantly became the station operator. Fortunately, there were a couple of students willing to do the mindless chore of processing the filters and sending them off to the EPA's laboratory. Until one day . . .

Adrián literally triggered the creation of this project by initiating a conversation questioning the relevance of the RadNet reporting protocol. As a few additional students joined the group this project became a student centered, student driven project.

The group proved to me the value of this project by creating two presentations for the 2013 National Council on Undergraduate Research Conference: *Expansion Of EPA RadNet Protocol For Dosimetry* (paper presented by: Adrián Sanabría-Diaz and Kayla M^{c}Mahon), and *Data Analysis Of An Expansion Of The EPA's RadNet Radiation Dosimetry Protocol* (poster presented by: Joshua Moravec)

In addition they demonstrated their commitment to student initiated, and student oriented education by creating a presentation for the 2014 NCUR Conference: *An Analysis Of Student Designed Courses* (paper presented by: Jeff Brittenham, Kayla M^{c}Mahon)

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[1] G. N. Whyte and H. W. Taylor, Am. J. Phys. **30**, 120 (1962);