Journal of Environmental Radioactivity 143 (2015) 52–57

Contents lists available at ScienceDirect

Journal of Environmental Radioactivity

journal homepage: www.elsevier.com/locate/jenvrad

Development of criteria used to establish a background environmental monitoring station

Bradley G. Fritz*, J. Matthew Barnett, Sandra F. Snyder, Lynn E. Bisping, Jeremy P. Rishel

Pacific Northwest National Laboratory, 902 Battelle Blvd., Richland, WA 99354, USA

ARTICLE INFO

Article history:
Received 9 January 2015
Received in revised form
9 February 2015
Accepted 10 February 2015
Available online 2 March 2015

Keywords:
Background monitoring
Environmental monitoring
Airborne Radioactivity
Air Sampling

ABSTRACT

It is generally considered necessary to measure concentrations of contaminants-of-concern at a background location when conducting atmospheric environmental surveillance. This is because it is recognized that measurements of background concentrations can enhance interpretation of environmental monitoring data. Despite the recognized need for background measurements, there is little published guidance available that describes how to identify an appropriate atmospheric background monitoring location. This paper develops generic criteria that can guide the decision making process for identifying suitable locations for background atmospheric monitoring station. Detailed methods for evaluating some of these criteria are also provided and a case study for establishment of an atmospheric background surveillance station as part of an environmental surveillance program is described. While the case study focuses on monitoring for radionuclides, the approach is equally valid for any airborne constituent being monitored. The case study shows that implementation of the developed criteria can result in a good, defensible choice for a background atmospheric monitoring location.

1. Introduction

Background monitoring data is generally considered a necessary component of atmospheric environmental surveillance (NCRP, 2010; IAEA, 2010; U.S. DOE, 1991; Keith, 1991; Kathren, 1984; Klement, 1982; WHO, 1968). This is because it is recognized that measurements of background concentrations can enhance interpretation of environmental monitoring data. For example, background concentrations provide a point of reference for other measurements on or near a site with emissions. If on-site samples were reported to have elevated concentrations, the initial assumption would be that the elevated concentrations resulted from on-site releases. However, results from samples collected at a background location could provide evidence for another explanation (e.g., regionally elevated concentrations).

While many published works identify and stress the need for background atmospheric monitoring locations when establishing monitoring networks (i.e., IAEA, 2010; NCRP, 2010; Meinke and Essig, 1991), there is little published guidance provided about how to identify an appropriate background location. How far away is far enough? How far is too far? These are questions not adequately addressed in available literature.

This paper develops generic criteria that can guide the decision making process for identifying suitable locations for background atmospheric monitoring station. Additionally, some detailed methods for evaluating potential locations against the criteria are provided. Finally, a case study is presented that focuses on the establishment of an atmospheric background surveillance station for the measurement of radionuclides associated with an environmental surveillance program.

2. Background siting criteria

Various definitions of background values and locations have been published. The NCRP (2010) defines background radiation as "the level of radiation from sources other than the source of interest". Control samples are defined by Keith (1991) as being collected near the time and place where the analytes of interest may exist, and used to determine if concentrations measured on a site are truly different from background concentrations. The IAEA (2010) notes that "A reference sampler might be located in an area where the natural background levels are similar to those at the site, but where the influence of discharges from the facility is negligible".

* Corresponding author. Tel.: +1 509 371 7119.
E-mail address: Bradley.Fritz@pnnl.gov (B.G. Fritz).

http://dx.doi.org/10.1016/j.jenvrad.2015.02.010

While these definitions provide some context for background locations, none of them are ideal or specific to background levels of contaminants in ambient air. Using these definitions as a guide, the following definition of an *ideal* background air monitoring location is proposed:

> "An ideal background air monitoring location is a point where the measured concentrations of analytes of interest are equal to the concentrations that would be measured at the site *if* operational emissions did not occur."

Based on this definition of an ideal background monitoring location, a list of general criteria, and approaches for evaluating potential sites against those criteria, were developed. These are generic requirements that could be applied anywhere to assist in establishing an environmental surveillance background air monitoring station, and are presented in order of importance.

A. Air concentration of each constituent of concern measured at a background location should be relatively uninfluenced by facility emissions. The acceptable level of influence a facility emission has on the concentration measured at a background location will be different for different programs. However, the increase in concentration at the background location caused by facility emissions should be less than the total acceptable error associated with the measurement.
   1. Atmospheric modeling can be used to estimate the dilution of emissions, and the corresponding impact to background concentrations, at varying distances away from the source.
   2. The estimated change in measured background concentrations caused by influence of facility emissions can be evaluated relative to the program's stated acceptable error.

B. The air sampled at a background location should be typical of the air sampled at or near the facility (except for those constituents of concern [COCs] emitted from the facility). That is to say, analytes other than the COCs should have similar concentrations at the background location and the facility.
   1. Qualitative assessment of the source facility and potential background locations are sufficient to meet this criterion. Background monitoring locations should be in an area with comparable land use and cover, similar anthropogenic emissions, etc.

C. Typical weather conditions (e.g., inversions, dust storms, precipitation, prevailing wind patterns) at the facility should also occur at the background station (Glantz, 1990).
   1. Knowledge of current and historic local weather patterns can be sufficient to qualitatively assess the representativeness of the background location with respect to weather. For examples, wind roses and precipitation maps could be useful.

D. The background location should be established at a reasonable distance away from the emission source (i.e., not too close or too far away). A reasonable distance is a function of the size of the emission source and magnitude of emission, but generally should be as close as possible while still meeting the other requirements. The reasonable distance should also consider a worst-case scenario with wind blowing directly from the source to the background location.
   1. Gaussian plume dispersion modeling under worst case dispersion conditions is sufficient for determining the minimum distance for a background location.
   2. Project resources should be considered in determining the maximum acceptable distance (e.g. cost of driving to station for sample collection).

E. Terrain should be a secondary consideration in this evaluation, considered after the initial modeling effort (for models that do not consider terrain in the dispersion calculation). This consideration is related to Criterion D.
   1. Atmospheric modeling with terrain effects or an evaluation of wind patterns and topographic maps can be used to qualitatively assess the representativeness of the background location.

F. All necessary infrastructure must be available (i.e., power, pavement, communications)
   1. Once a general area is identified as meeting the large scale requirements (Criteria A–E), potential specific locations within that area can be identified.

G. The sampling location must meet general siting requirements for an air sampling location (e.g., minimal obstructions, no nearby sources, minimal impact to environment, adequate security and safety provisions, accessible by staff).
   1. Potential sampling locations should be evaluated against siting requirements. If projects do not have established siting criteria, refer to published meteorological tower siting requirements for guidance (i.e. U.S. EPA, 2000; U.S. NRC, 2007).
   2. Consider if there are any unique siting requirements specific to the sampling equipment used.

Some optional considerations include:

H. Co-located sampling by other agencies can be useful to provide backup data in the event of equipment failure, and for QA purposes.
   1. Local regulatory agencies should be able to provide a list of other active and relevant monitoring programs in the area.

I. Historic data from previous/other sampling program(s) can be useful for comparison and QA purposes.
   1. A literature review should provide information about historic projects in the area.

2.1. Source to background dilution factor

Atmospheric dispersion models are used to estimate the dilution factor at varying distances from the source (Criterion A). The dilution factor is used to identify the distance away from the COC source at which concentrations would be diluted enough to be negligible. One consideration is the impact that overestimation of the true background can have on other measurements made on or near the site. If the background monitoring station is 'too close' to the site, then site emissions will be collected by the background monitor, and the reported background will be higher than the true background (as defined above). Therefore, it is necessary to locate the background station sufficiently far from the site such that the systematic error in the measured background created by collection of site effluent at the background location is less than the total acceptable error. For example, consider a program where the required accuracy of the reported concentration is ±20%. If the estimated random errors in the sample volume and analytical measurements are ±10 and 15% respectively, then the total combined error (calculated as the root mean square of the individual error terms for random errors) is 18% (Equation (1)). An additional 2% systematic error could then be contributed by collection of site emissions at the background location and still result in the total combined error being 20% (Equation (2)). Therefore, if a potential background location has an annual average concentration 1/50th of the concentration estimated at the site boundary (or less), then that location might be considered acceptable for use as a background location because the small amounts of effluent collected at the background station will be indistinguishable from the random sampling error. For programs with lower tolerance for error, a lower dilution factor may be necessary