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Scoping Calculations for Monitoring of Aggressive Air Sampling

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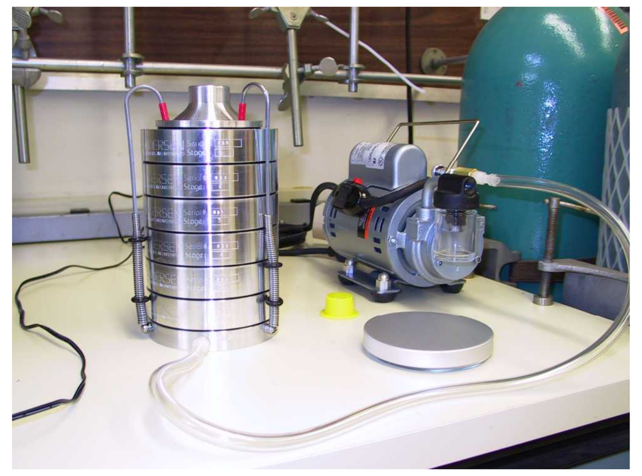
Introduction

Aggressive Air Sampling (AAS) consists of putting a room under negative pressure, aggressively suspending any particulate material, keeping the particulates well mixed within the room and using an air monitor to sampling airborne particulate concentrations for some time period. AAS has been used for confirmatory sampling in restoration of buildings contaminated with anthrax. However, current guidelines for AAS are based on those developed for asbestos abatement. Questions remain as to optimal values of operating parameters such as the sampling rate, the rate of air removal from the room under negative pessure and the necessary sampling time. This work uses a previously developed set of analytical solutions (Ott et al., 2003) to examine how varying AAS operating parameters affects the fraction of the initial contaminant mass that is collected on the sampling filter.

AAS in action!

A fan blower being used to suspend particulates (left) and the air sampler (right)



Recommended Implementation

The main application of aggressive air sampling has been for confirmatory sampling in asbestos abatement projects. The primary guidance for these applications is US EPA, (1985). The room being sampled should be kept under negative pressure such that four room volumes per hour are exchanged. The following recommended practices for AAS in asbestos abatement projects are defined:

1) Before starting the sampling pumps, direct the exhaust from forced air equipment (such as a 1 hp leaf blower) against all walls, ceilings, floors, ledges and other surfaces in the room. This should take at least 5 minutes per 1000 sq. ft. of floor.
2) Place a 20-inch fan in the center of the room. (Use one fan per 10,000 cubic feet of room space.) Place the fan on slow speed and point it toward the ceiling.
3) Start the sampling pumps and sample for the required time.
4) Turn off the pump and then the fan(s) when sampling is complete.

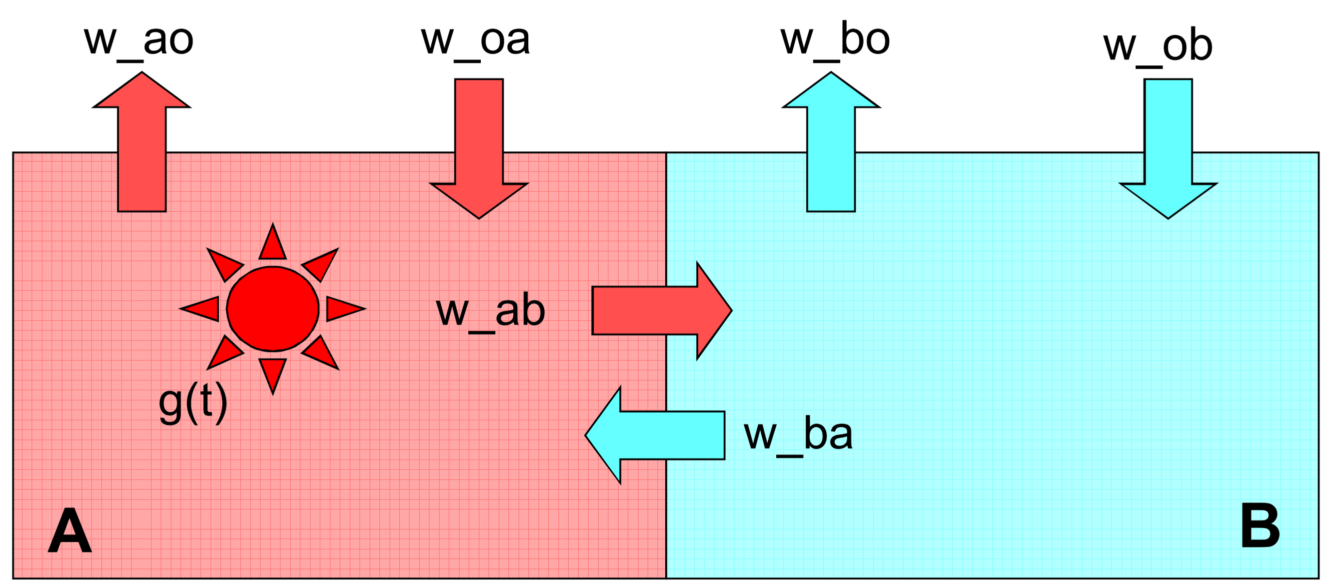
The EPA guidance provides recommended air sampling volumes, but these are based on detection limits for prescribed asbestos analyses and are not necessarily applicable for AAS of biological agents

Modeling Assumptions

Application of the solutions developed by Ott et al., 2003 to the problem of AAS for particulates require some assumptions: 1) The particulates behave as perfect tracer (settling velocity is zero and they do not clump together); 2) The source is an instantaneous pulse that completely mixes the source mass throughout the room volume at time = 0; and 3) The outdoor concentration remains negligble throughout the modeled time period

Two Compartment Model

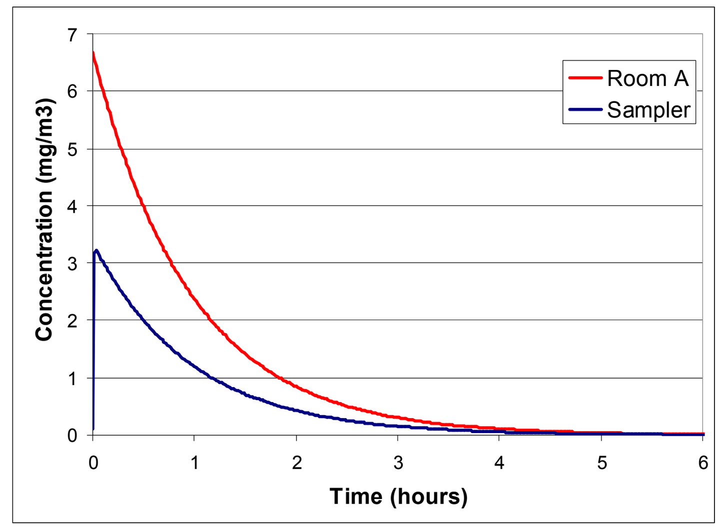
The two-compartment model allows for air exchange between the two compartments, rooms A and B, as well as air exchange between each compartment and the outdoors. The time varying contaminant source, g(t), is located in Room A

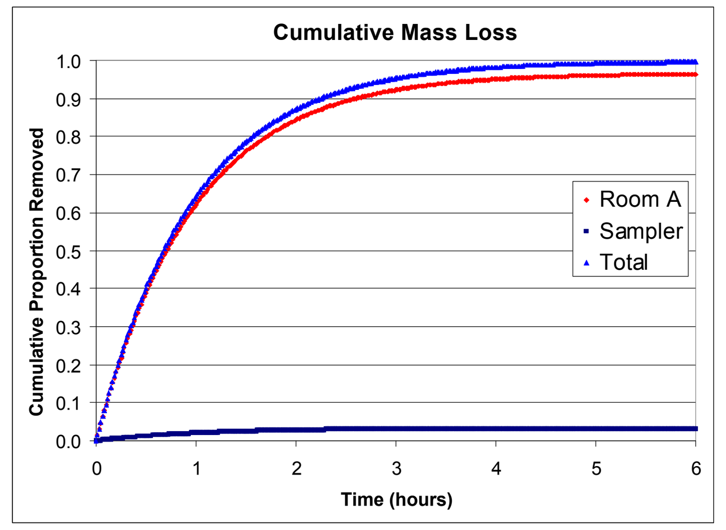


The two-compartment model is parameterized with the volumes of each compartment, the airflow rates between the compartments and the time varying source located in room A.

Air Sampling Calculations

This two-compartment model is adapted to conceptualize room B as the air sampler, by reducing the volume of room B. Removal of contaminants by the filter within the air sampler is modeled as removal of contaminants from room B to the outdoors. Equations for the cumulative contaminant removal by the filter with the air sampler are developed. The figures below show results of an example calculation with the time varying concentration within the room and the air sampler (left) and the cumulative amount of the source mass captured by the air sampler filter. The source is considered to be an instantaneous pulse within room A



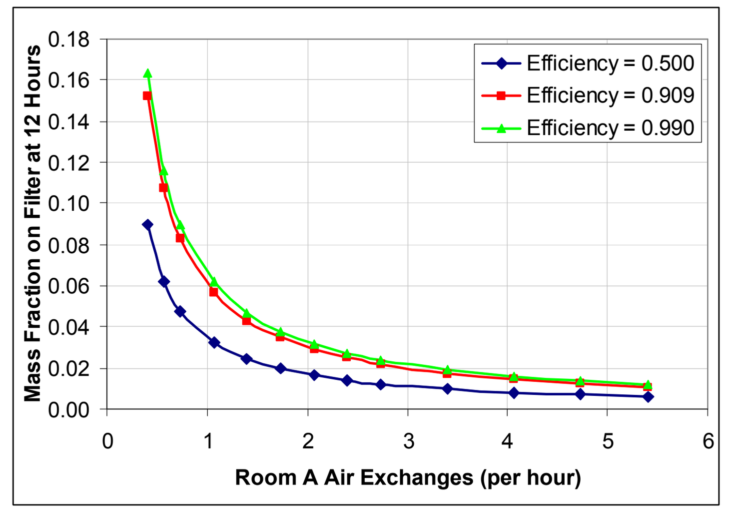


Parameters for these calculations include room volumes of 150 and 0.1m^3 for room A and the sampler, w_oa = w_ao = 150m^3/hr, w_ab = w_ba = 10m^3/hr, sampling efficiency = 0.50. The fraction of the initial mass extracted by the filter at 12 hours is 0.032

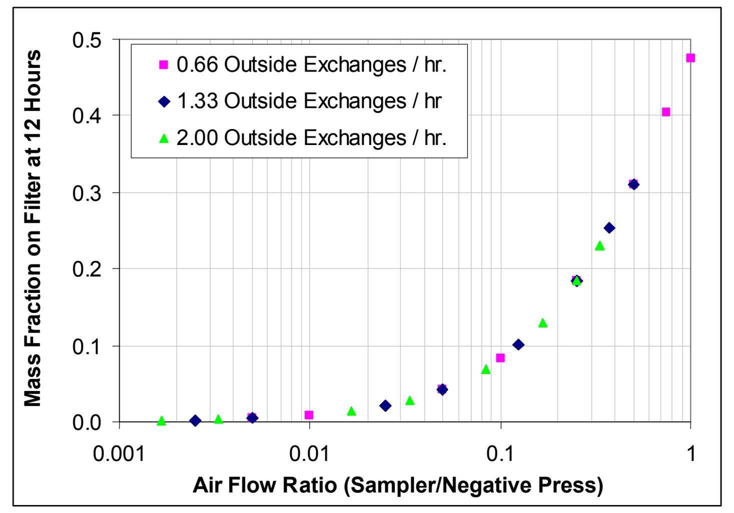
Results

A wide variety of parameters can be varied to examine the performance of air monitoring in a AAS scenario. Here we examine the effect of varying the sampling efficiency and the ratio of the air flow rate into the sampler over the rate of air loss due to negative pressure. In both cases, the fraction of the initial source mass collected on the sampling filter 12 hours after the AAS began is used as a performance measure.

The contaminant mass fraction recovered after 12 hours as a function of the rate of air exchange in room A is shown on the right. Three different sampler efficiencies are examined by modifying the air flow rates to the filter (outdoors) relative to the air flow into the sampler. The rate of air flow into the sampler is held constant across all calculations at 10 m^3/hr (167 liters/min)



The contaminant mass fraction recovered after 12 hours as a function of the ratio of air entering the sampler to air leaving room A under negative pressure is shown on the right. Sampler efficiency is held at 0.909. Three different rates of outside air exchange due to negative pressure are examined (100, 200 and 300 m^3/hr). Sampling rates are varied from 0.5 to 100 m^3/hr (8.3 to 1667 liters/min)



Summary

Analytical solutions for time varying concentration in a two-compartment model provide a means of examining air monitoring performance for AAS scenarios. A limited set of calculations show that the ratio of the sampling rate to the rate of air removal due to negative pressure is a key factor in determining the amount of mass collected on the sample filter. This ratio needs to be as close to 1.0 as possible which will generally require air exchange rates due to negative pressure to be less than 1/hour. This rate is below the currently recommended 4 exchanges per hour. In all cases examined here, a 12 hour monitoring period was sufficient for > 99% of all mass to leave the system. Using additional samplers to increase the total flow rate into the sampler may not help as this will add additional filters and act to further reduce the mass fraction on any one filter

References

US EPA, 1985, Guidance for Controlling Asbestos-Containing Materials in Buildings; EPA 560/5-85-024, U.S. EPA, Washington, DC, 114 pp.

Ott,W.R., N.E. Klepeis and P. Switzer, 2003, Analytical Solutions to Compartmental Indoor Air Quality Models with Application to Environmental Tobacco Smoke Concentrations Measured in a House, *Journal of the Air and Waste Management Association*, 53, pp. 918-936.