Indoor Air Sampling of VOCs: Long-Term Passive Diffusion Devices Challenge Study with Comparison to Active Method

Harry S. O'Neill (**harry.oneill@beacon-usa.com**) and **Steven C. Thornley** (Beacon Environmental Services, Bel Air, Maryland, USA)

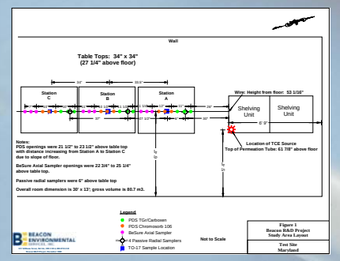
OVERVIEW

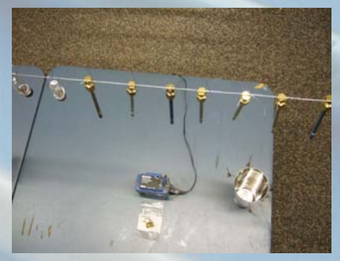
The purpose of the research is to compare the results from long duration sampling periods using a variety of passive diffusion samplers to the results from 24-hour sampling periods using sorbent tubes and low-flow pumps (EPA Method TO-17), which were collected throughout a 14-day study period. A controlled release in a large room of trichloroethylene (TCE) with one and two orders of magnitude daily concentration variability throughout the course of a two-week monitoring event provided the basis for the study. The daily concentration measurements by EPA Method TO-17 and the multi-day passive diffusion samplers were performed in triplicate.

The results from the 24-hour active samples were averaged and compared with the passive diffusion devices exposed to indoor air for 3, 7, 10, and 14 days in accordance with ASTM D6196-02. A specific uptake rate for each of the passive devices at the four different time intervals and the statistical significance of the time-varying uptake rates were evaluated for TCE. The average concentrations for all exposure periods were calculated using the established uptake rates of the passive devices that passed a predefined coefficient of variation criteria.

METHODOLOGY

Shown below is the overall layout of the sampling stations for the monitoring of the controlled release of TCE in a large room. Three sampling stations were set up and are denoted as Sampling Stations A, B and C. The photograph shows an overhead shot of Sampling Station A. Three types of axial passive devices are suspended evenly across a horizontal wire and a fourth type of passive device (radial) is on the table below to the right of an active sampling pump that was used to collect samples following EPA Method TO-17.





During the 14-day study period, a sample was collected daily at each of the three stations using the low flow sampling pumps and adsorbent tubes packed with two beds of adsorbent. The pump flow rate was ~20 mL/min and was measured at the beginning and end of each daily sampling event.

Forty eight (48) passive collection devices were deployed the first morning. Four different passive devices were used with three axial types and one radial type as summarized below:

- PT -- TenaxGR/Carboxen Passive Axial Tube Sampler
- PC -- Chromosorb 106 Passive Axial Tube Sampler
- BA – BeSure Passive Axial Sampler
- PR -- Passive Radial Sampler

RESULTS

An uptake rate was calculated for each of the passive devices for each of the four exposure periods. Samples were collected in triplicate. * The uptake rate is based on the average TO-17 concentration, the average mass measured on the passive device, and the exposure period, which is expressed below:

Uptake Rate = Average Mass from Passive Device / (Average Concentration * time)

Units: $cm^3/min = [ng / (ug/m^3 * min)] * 1000$

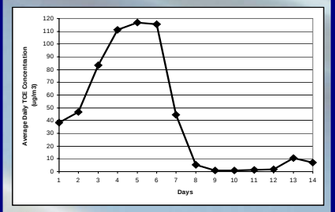
The following table is a summary of the uptake rates calculated for each of the four exposure periods (3, 7, 10, and 14 days). The uptake rates are fairly consistent over time even though the concentration variability on a daily basis was large. The coefficient of variation (CV) was lowest for the single sorbent tube (PC) and highest for the multiple sorbent tube (PT). The radial sorbent configuration (PR) had the highest uptake rate by an order of magnitude. The BeSure Axial Sampler (BA) uptake rate was nearly identical to PT (same sorbent make-up); however, the BA CV was four times lower.

	Uptake Rate (cm3/min)						Coefficient of Variation
Type/Days	3	7	10	14	Avg	Std Dev	
PC	0.23	0.25	0.23	0.24	0.24	0.008	0.036
PT	0.21	0.11	0.14	0.13	0.15	0.044	0.300
BA	0.14	0.16	0.14	0.15	0.15	0.011	0.074
BR	1.57	1.85	1.85	2.81	2.02	0.543	0.268

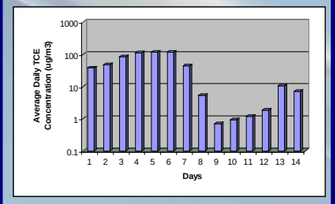
* On two of the fourteen days there was a pump interruption. On those two days, there were duplicate samples.

Daily TCE Concentrations

The following graph shows the daily TCE concentration measured with the TO-17 samples. The first four days were a steady rise in concentration (to Day 4), the next two days the concentration leveled out followed by a quick drop (to Day 7), the next three days it continued to drop to very low levels (to Day 10), and the last four days another TCE spike but at much lower levels (to Day 14).

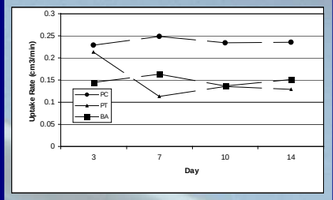


Two orders of magnitude daily average TCE concentrations were achieved as shown on the following plot.



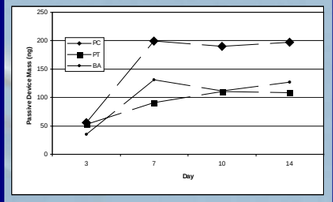
Uptake Rates from Axial Devices

The following graph shows the calculated uptake rates of the three axial devices for each of the four exposure periods. The data consistency is of high quality.



Passive Mass Collected from Axial Devices

The following graph shows the average mass of TCE collected in the three axial devices. The dynamics of the daily TCE concentration variability are reflected with the passive data.



PROJECTIONS FROM ESTABLISHED UPTAKE RATES

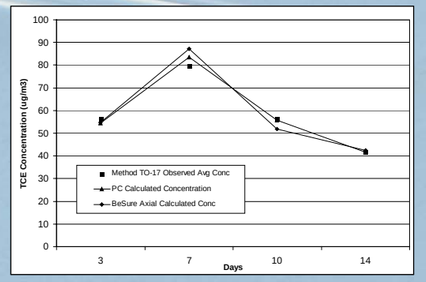
For each passive device, the average uptake rate from the four sampling events was then applied to each individual sampling event using the following equation:

Concentration = Mass from Passive Device / (Uptake Rate * time)

Units: $ug/m^3 = [ng / (cm^3/min * min)] * 1000$

The TCE concentration calculated with the average uptake rate was then compared to the average TCE concentration measured with the TO-17 samples. The PC and BA passive devices (both axial devices) were found to have the most consistent uptake rates throughout the study even as concentrations varied by orders of magnitude (CV<0.10).

The following graph shows the average TCE concentrations for each exposure period as determined by the TO-17 samples plotted against the calculated concentrations based on the average uptake rates for the PC and BA devices. As the chart shows, passive devices with a COV less than 0.10 maintained a strong agreement to the TO-17 measurements even as the daily concentrations varied by orders of magnitude. The uptake rates for the PT and PR devices were found to be not as reliable, with CVs of 0.300 and 0.268, respectively.



CONCLUSIONS

A controlled release of TCE in an a large room to reflect real world conditions allowed for over two orders of magnitude daily concentration variability over the course of the two-week monitoring event.

The daily concentration measurements by EPA Method TO-17 and the passive diffusion samplers were done in triplicate and had excellent reproducibility.

The coefficient of variation of the uptake rate was lowest for the single sorbent tube (PC) and highest for the multiple sorbent tube (PT). The radial sorbent configuration (PR) had the highest uptake rate. The BeSure Axial Sampler (BA) uptake rate was nearly identical to PT (same sorbent make-up); however, the BA coefficient of variation was four times lower at 0.074.

The TCE uptake rate for the PC configuration is approximately half of that reported in a previous laboratory study (MDHS80) for shorter duration sampling and may be more representative of real world conditions with longer duration sampling periods.

The performance of all the passive diffusion devices was analyzed in this study for large fluctuations of TCE concentrations. The average concentration for all of the exposure periods could be reliably predicted using the established uptake rates and without the need for pumps or vacuums for the PC and BA devices. The PT and PR devices' coefficients of variation were above 0.10 and did not produce reliable concentration estimates.

Contact **Beacon Environmental Services, Inc.** at www.beacon-usa.com or 1-410-838-8780 for further information.

Background picture courtesy of Markes International