Evaluation of USEPA’s Empirical Attenuation Factor Database

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Background

- USEPA introduced the use of default $\alpha$’s for Tier 2 generic screening in its 2002 draft vapor intrusion guidance.
- The 2002 default $\alpha$’s for subslab soil gas and groundwater were based on an USEPA database of empirical $\alpha$’s.
- In 2008, USEPA released an updated database and a draft report suggesting that the new database supports the 2002 default $\alpha$’s.
- In finalizing its vapor intrusion guidance, USEPA is likely to cite the 2008 database and draft report for default $\alpha$’s.
- USEPA has indicated that it may require using default $\alpha$’s for not only generic screening but also for replacement of semi-site-specific screening and site-specific assessment.
Evaluation of the 2008 Database and Draft Report

- Key Questions

  - Is the 2008 database robust enough to derive default $\alpha$’s that can obviate the need for estimating $\alpha$’s that account for site-specific conditions?

  - Are the recommended default $\alpha$’s reasonable for generic screening?
Representativeness of the 2008 Database

- About 90% of the empirical α’s are for residential buildings (mostly with basements).
- Most of the subslab and soil gas α’s are for coarse- or very coarse-grained soil.
- A vast majority of empirical α’s for fine-grained soil are limited to the groundwater α’s.
- Almost all of the empirical α’s are for chlorinated VOCs (as opposed to BTEX).
- The empirical α’s are not broken down by other factors that can strongly influence vapor intrusion, such as the depth of the contaminant source.
Deriving Default $\alpha$’s from the 2008 Database

- USEPA recognized the database included empirical $\alpha$’s that are high-biased by indoor sources.

- In the 2008 draft report, empirical $\alpha$’s were to be excluded from further consideration if:
  - field notes indicated the presence of background sources
  - indoor air concentration was higher than subsurface concentration
  - a chemical’s $\alpha$ was inconsistent with other chemicals’ $\alpha$’s in a sample
  - indoor air concentration was lower than the 95th percentile indoor air background level or analytical reporting limit

- These criteria eliminated the following percentages of $\alpha$’s:
  - 80% for subslab
  - 64% for soil gas
  - 59% for crawl space
  - 44% for groundwater
Distribution of $\alpha$ as Background Bias is Reduced
Additional Criterion for Reducing Background Bias

- For the following single-zone, well-mixed indoor space:

\[ Q_{\text{bldg}} C_o \rightarrow \text{Indoor Sources} \rightarrow (Q_{\text{bldg}} + Q_{\text{soil}}) C_{\text{bldg}} \]

\[ R_i \]

\[ Q_{\text{soil}} C_{ss} \]

- A mass balance analysis shows that:

\[ \tilde{\alpha}_{ss} \equiv \frac{C_{bldg}}{C_{ss}} = \frac{Q_{soil}}{Q_{bldg}} + \frac{C_i}{C_{ss}} \]
Additional Criterion for Reducing Background Bias

- Indoor sources will inflate subslab α’s by 2X or more when $C_i/C_{ss}$ equals or exceeds $Q_{soil}/Q_{bldg}$.

- Using USEPA-recommended assumptions for a residential building with basement, $Q_{soil}/Q_{bldg}$ is approximately 0.003.

- This is similar to a ratio of 0.0016 that has been derived for radon entry into single-family homes.

- This means $C_{ss}$ should be approximately 300X higher than $C_i$ to minimize background bias on empirical subslab α’s.
Further Reducing Background Bias Using “300X” Criterion
Review of these 217 α’ s showed that 97 have confounding factors or other characteristics that indicate a potential for background bias.

These α’ s include 19 outliers (higher than Q_{0.75}+1.5*IQR).

USEPA’s default α of 0.1 is at the 99.5^{th} percentile.
Key Points

- The 2008 database has a very limited number of empirical \( \alpha \)'s for nonresidential buildings, fine-grain soil, or petroleum hydrocarbons.

- In deriving default \( \alpha \)'s, USEPA had to exclude most of the empirical \( \alpha \)'s in the database to minimize background bias.

- We found that empirical \( \alpha \)'s for residences will be inflated unless they are based on subsurface concentrations that are at least 300X higher than indoor background levels.

- USEPA’s default subslab \( \alpha \) of 0.1 is based on empirical \( \alpha \)'s that include many with \( \frac{C_{ss}}{C_i} \) ratios much less than 300.

- USEPA’s default groundwater \( \alpha \) of 0.001 does not have this problem.