Advances in Modeling Individual-Based Exposures Estimates to VOCs

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by

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Presentation Overview

• Modeling subjects: the adult participants of the Relationships among Indoor, Outdoor and Personal Air (RIOPA) study (Weisel et al., 2004)
  • Distributions of the outdoor, indoor, personal samples
  • Distributions of the ratios of indoor/outdoor samples
• Individual-Based Exposure Modeling (IBEM) framework of the MENTOR/SHEDS-1A system
• IBEM applications for the three RIOPA study areas (Elizabeth, NJ; Houston, TX; Los Angeles, CA)
  • Environmental modeling characterization
  • Microenvironmental modeling
  • Activity pattern and exposure modeling
The RIOPA Study Area: Elizabeth, NJ

(a) Locations of sampling homes and surrounding meteorological and air quality monitoring stations
(b) Cumulative Distribution Functions of Benzene samples
(c) Cumulative Distribution Functions of Formaldehyde samples
The RIOPA Study Area: Houston, TX

(a) Locations of sampling homes and surrounding meteorological and air quality monitoring stations
(b) Cumulative Distribution Functions of Benzene samples
(c) Cumulative Distribution Functions of Formaldehyde samples
The RI OPA Study Area: Los Angeles, CA

(a) Locations of sampling homes and surrounding meteorological and air quality monitoring stations
(b) Cumulative Distribution Functions of Benzene samples
(c) Cumulative Distribution Functions of Formaldehyde samples
Distributions of Indoor/Outdoor Ratios across Three RI OPA Cities

Cumulative Distribution Functions (CDF) of Indoor/Outdoor ratios for (a) Benzene (b) Formaldehyde across the three RI OPA cities (Elizabeth, NJ: Houston, TX: Los Angeles, CA)
IBEM Framework of the MENTOR/SHEDS-1A System

1. Estimate background levels of air pollutants through either:
   a. multivariate spatiotemporal analysis of monitor data
   b. emissions-based air quality modeling (with regional, grid-based models: Models-3/ CMAQ, CAM-x and REMSAD)

2. Estimate local outdoor pollutant levels that characterize the ambient air of an administrative unit (such as a census tract) or a conveniently defined grid through either:
   a. spatiotemporal statistical analysis of monitor data
   b. subgrid “corrections” of multiscale model estimates
   c. application of a local scale air quality model such as ISCST, AERMOD, etc.

3. Develop database of individual subjects attributes (residence and work location, housing characteristics, age, gender, race, income, etc.)
   a. collect study-specific information
   b. supplement study-specific information with available, relevant local, regional and national information

4. Develop activity event (or exposure event) sequences for each individual of the study for the exposure period
   a. collect study-specific information
   b. supplement study-specific information with other available data
   c. organize time activity database in format compatible with CHAD

5. Estimate levels and temporal profiles of pollutants in various microenvironments (streets, residences, offices, restaurants, vehicles, etc.) through either:
   a. regression of observational data
   b. simple linear mass balance
   c. detailed (nonlinear) gas/aerosol chemistry models
   d. detailed combined chemistry & CFD models.

6. Calculate appropriate inhalation rates for the members of the sample population combining the physiological attributes of the study subjects and the activities pursued during the individual exposure events
   a. ICRP and Other Physiological & METS Databases

7. Biologically Based Target Tissue Dose Modeling

Calculate Exposures/Intakes

Calculate Potential Outdoor Exposures

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1999 Annual average ambient concentrations of (a) Benzene (b) Formaldehyde calculated by the ASPEN model

Data source: 1999 NATA study (USEPA, 2005)
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Comparison of 1999 NATA Estimates with RIOPA Outdoor Samples

Note: RIOPA data were sampled during the period of June 1999 – January 2001
Time-Activity Patterns of the RI OPA Study Subjects

Percentages of time spent in five microenvironments (home, office/school, other indoor, outdoor, in vehicle) of the RI OPA subjects during the 48-hour sampling period.
Cumulative Distribution Functions (CDF) of Benzene (1st column) and Formaldehyde (2nd column) in five microenvironments calculated by MENTOR/ SHEDS-1A with the inputs of ambient concentrations from (a) RIOPA outdoor samples, (b) 1999 NATA estimates.
Cumulative Distribution Functions (CDF) of Benzene (1st column) and Formaldehyde (2nd column) in five microenvironments calculated by MENTOR/ SHEDS-1A with the inputs of ambient concentrations from (a) RIOPA outdoor samples, (b) 1999 NATA estimates.
Microenvironmental Modeling: Los Angeles, CA

Cumulative Distribution Functions (CDF) of Benzene (1st column) and Formaldehyde (2nd column) in five microenvironments calculated by MENTOR/ SHEDS-1A with inputs of ambient concentrations from (a) RIOPA outdoor samples, (b) 1999 NATA estimates.
Exposure Modeling: Elizabeth, NJ

Cumulative Distribution Functions (CDF) of 48-hour average exposure concentrations of (a) Benzene (b) Formaldehyde generated from the RIOPA personal samples and corresponding MENTOR/SHEDS-1A calculations with inputs of ambient concentrations from RIOPA outdoor samples and 1999 NATA estimates, respectively.

(a) (b)
Cumulative Distribution Functions (CDF) of 48-hour average exposure concentrations of (a) Benzene (b) Formaldehyde generated from the RIOPA personal samples and corresponding MENTOR/SHEDS-1A calculations with inputs of ambient concentrations from RIOPA outdoor samples and from 1999 NATA estimates, respectively.
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Cumulative Distribution Functions (CDF) of 48-hour average exposure concentrations of (a) Benzene (b) Formaldehyde generated from the RIOPA personal samples and corresponding MENTOR/SHEDS-1A calculations with inputs of ambient concentrations from RIOPA outdoor samples and from 1999 NATA estimates, respectively.

(a) Benzene

(b) Formaldehyde
Preliminary Conclusions and Discussion

• The IBEM approach of the MENTOR/SHEDS-1A was applied to assess personal exposures to benzene and formaldehyde for the RIOPA study subjects.

• Different inputs of ambient concentrations (RIOPA outdoor measurements vs. 1999 NATA estimates) were used to simulate personal exposures:
  • Calculated personal exposures based on RIOPA outdoor measurements showed reasonable agreement with measured personal samples.
  • The above simulation results underestimate personal exposures, most probably due to the lack of modeling exposure contribution from indoor sources.
  • The degree of underestimation is higher for modeling exposures to formaldehyde than benzene.

• On-going effort and future work:
  • Local-scale air quality modeling using USEPA’s EMS-HAP/IS CST3 models for the actual days of RIOPA sampling.
  • Development of modules to account for contributions of indoor sources of air toxics.
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