Needs and Opportunities in Exposure Characterization for Homeland Security Events

by

P.J. Lioy, S. Isukapalli, and P.G. Georgopoulos

Exposure Science Division,
Environmental and Occupational Health Sciences Institute (EOHSI)
170 Frelinghuysen Road, Piscataway, NJ 08854
Definition: Human Exposure Science

The study of:

- human contact with chemical, physical or biological agents occurring in their environments, and advances in knowledge of the mechanisms and dynamics of events either causing or preventing adverse health outcomes.

What is an Exposure?

An Event requiring “Contact” with an agent

- *** Short or long,
- Continuous, periodic or singular
- Individuals, sub-population, or general population

Can be Measured

- Directly
- Indirectly

Can be Simulated by

- Exposure Models
- Source to Dose Models, and Systems
Human Exposure Science and Preparedness

Missing From Most Exercises

- Integration of local buildings, traffic and human activities
- Nature and realistic distribution of the release
- Spatial distribution of contamination
- Population at risk: temporal and spatial, age, and activities
- Population response to event – decreasing or increasing primary or secondary “contact”

NOTE: Each of the above are part of exposure science and are currently part of typical environmental health problem solving.
Fact: *time and geographic location* must link to the dynamic microenvironmental attributes, demographic and physiological characteristics, activity patterns, etc. differentiate the exposures and doses that result from an environmental/emergency event.
Process Continuum From Emission of a Contaminant to a Health Effect

Why Exposure Science should not be Ignored: It bridges the analysis from identification of the source to reality of impacts at the human receptor

Lioy, 1990, 1999; Adapted
Anthrax Exposure - Infectivity Model

• Physically based modeling of source to dose and effects
• Modular, so that individual components can be independently refined, including

• Realistic distributions of demographics, human activity patterns, etc.
Plume Modeling: 100g Release of Anthrax over 10 Hours

(a) Instantaneous Release

(b) Continuous Release
A Summary of Simulation Results

Total expected casualties in the affected seventy five DE census tracts:

• 1 hour release
  - MENTOR/SHEDS: 926 (Realistic Population Based Activity Patterns)
  - EPA EFH assumptions: 5,353 (No Activity Patterns)
  - Craft et al. assumptions: 10,893 (No Activity Patterns, higher Inhalation rate)

• 10 hour release
  - MENTOR/SHEDS: 876
  - EPA EFH assumptions: 6,427
  - Craft et al. assumptions: 13,804
The Bhopal Accident: A Significant Case Study of Population Activities and Exposure

On the early morning of December the 3rd 1984, in the town of Bhopal (State of Madhya Pradesh), a tank of methyl isocyanine gas blows up in Union Carbide plant. A toxic cloud stretches upon 40 sq/m and about thirty tons of gas are released. 20 000 people die during the night, mainly while sleeping, because of the non-existent alarm system. The ones who tried to escape from the disaster got sicker, by exposing themselves. There is no evacuation plan, and rescue is not adapted.
Prospective Plume Exposure Exercise: A Major Goal of Urban Dispersion Program (UDP) NYC

National security threats posed by terrorist acts or serious accidents require a better understanding of air flow, transport, and pollutant accumulation in active street canyons and commercial hubs within urban centers. Therefore:

• Prospective characterization of personal exposure to inert “gaseous” tracers at the surface moving towards and away from release points in such locations.
Neighborhood-Scale Personal Exposure Monitoring: 3/10/05
Neighborhood Scale Personal PFT Exposures for Paths AA- through DD: Source “on”: 9:00 AM to 9:30 AM

PFT release at 9:00-9:30 am, March 10, 2005
Neighborhood Scale Personal Exposures for Paths AA-through DD: Source “off”: 10:00 AM to 10:30 AM

PFT release at 10:00-10:30 am, March 10, 2005
Summary: Reasons Why Exposure Concepts Need to be included in Preparedness Analyses, Simulations and Exercises

1. Define the number of people potentially a risk during a small, medium or large event
2. Characterize or simulate the distribution of exposure and dose among susceptible subgroups
3. Define the number of potential victims in both space and time
4. Examine the strengths/weaknesses of response and preparedness programs
5. Improve situational awareness, intervention and recovery protocols
6. Provide educational opportunities for the general public
Human Exposure Science and Preparedness

Question Remains: Why don’t current exercises include such features?