Overview of the Benzene and other Toxics Exposure (BEE-TEX) Study

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BEE-TEX Contributors

- U.S. Fish and Wildlife Service
- Harris County, Texas
- Texas Environmental Research Consortium (TERC)
- Houston Advanced Research Center (HARC)
- University of California at Los Angeles (UCLA)
- Aerodyne Research, Inc.
- University of North Carolina at Chapel Hill (UNC)
- Rice University/University of Houston
- Port of Houston Authority
- Texas Department of Transportation (TxDOT)
- City of Houston
- Houston Regional Monitoring (HRM)
- Texas Environmental Justice Advocacy Services (TEJAS)
- Air Alliance Houston
Houston Cancer Risk from EPA 2005
National-Scale Air Toxics Assessment
BEE-TEX Field Study

• The Benzene and other Toxics Exposure (BEE-TEX) Study is a field study of human exposure to and source attribution of the air toxics: benzene, toluene, ethyl benzene and xylenes (BTEX), plus other HAPs (e.g., formaldehyde, 1,3-butadiene).

• The study will be conducted in the Houston Ship Channel neighborhoods of Manchester, Galena Park, and Milby Park in the spring of 2014.

• The study costs about $1 million and is funded by the U.S. Fish & Wildlife, Coastal Impact Assistance Program (CIAP) through Harris County, Texas.
BEE-TEX Methodologies

• Computer-Aided Tomography (CAT) scans based on Differential Optical Absorption Spectroscopy (DOAS) remote sensing
• Real-time mobile monitoring
• Portable cultured human lung cells
• HARC micro-scale 3D Eulerian chemical transport model for source attribution and CAT plume reconstruction
Long Path DOAS

- Measures total amount of substance over a long path using visible or UV light absorption.
- BTEX spectra below 290 nm, so cannot use sunlight. Must use artificial light source.
- Maximum path length obtained using bi-static configuration (no retro-reflectors) with LED light sources opposite detector.
- New bi-static system being tested at UCLA and at a refinery in Carson, CA.
Computer-Aided Tomography

CAT-DOAS with multiple light paths can be used to derive spatially resolved ambient concentrations (not just path averages) over an entire neighborhood.
Upper Diagram:
Concentration field resulting from a steady emission of 0.1 kg/s from a source at (550 m, 550 m) in the presence of a westerly wind of 5 m/s and symmetric eddy diffusion coefficient of 1000 m²/s.

Lower Diagram:
Computer Aided Tomography (CAT) reconstruction on a 1 km x 1km grid with 200 m spacing based on two DOAS instruments at southwest and southeast corners emitting 10 rays each (total = 20 rays). The CAT is performed based on the Algebraic Reconstruction Technique (ART).
AERODYNE MOBILE LABORATORY
• Real-time measurement capabilities:
  CO, CO₂, O₃, HCHO, VOCs, NOx, PM
  Wind speed & direction, temperature, humidity

SCIPUFF DISPERSION MODEL
• Complex wind flows
• Forward mode
• Inverse mode (AIMS)
## Mobile Lab Instrumentation

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Chemical Species</th>
<th>Time Resolution</th>
<th>Detection Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantum Cascade Lasers (QC-TILDAS)</td>
<td>formaldehyde, NO$_2$, CO, methane</td>
<td>1 s</td>
<td>0.5 – 0.7 ppb, but 3 ppb for methane</td>
</tr>
<tr>
<td>LiCor Non-dispersive Infrared Analyzer</td>
<td>CO$_2$</td>
<td>1 s</td>
<td>90 ppb</td>
</tr>
<tr>
<td>Proton Transfer Reaction Mass Spec.</td>
<td>BTEX and other VOCs/HAPs</td>
<td>2 s</td>
<td>2 ppb (0.3 ppb at 1 min)</td>
</tr>
<tr>
<td>Chemiluminescence</td>
<td>NO</td>
<td>1 s</td>
<td>0.5 ppb</td>
</tr>
<tr>
<td>UV Absorbance Photometer</td>
<td>ozone</td>
<td>1 s</td>
<td>2% accuracy</td>
</tr>
<tr>
<td>Gas Chromatograph w/ Flame Ionization Detec.</td>
<td>VOCs/HAPs</td>
<td>5 min sampling</td>
<td>a few ppb</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25 min analysis</td>
<td></td>
</tr>
<tr>
<td>Aerosol Mass Spectrometer</td>
<td>organic, sulfate, nitrate, chloride PM</td>
<td>1 min</td>
<td>a few ng/m$^3$</td>
</tr>
<tr>
<td>Multi-angle Aerosol Absorption Photometer</td>
<td>soot</td>
<td>2 s</td>
<td>5 µg/m$^3$</td>
</tr>
</tbody>
</table>
UH/Rice Mobile Lab
Cultured Human Lung Cells

• UNC will deploy *in vitro* technique for one week during the BEE-TEX campaign.

• Living lung cells will be exposed to polluted air delivered across an air-liquid interface.

• Cell toxicity & inflammation measured based on releases of specific proteins and enzymes.

• Cell responses may indicate exposure to specific classes of pollutants (e.g., aldehydes).
HARC Contributions

• Advanced 3D micro-scale modeling
• Source attribution
• Web portal for information dissemination
• Real-time data broadcasting
• HARC mobile lab equipped with PTR-MS and meteorological instrumentation
• Synthesis of major field study results
Dissemination of Preliminary Results

- Journal of Environmental Health Insights is a peer-reviewed, open access journal
- Aimed at health research community
- Special supplement on ambient air quality
- Sub-section of supplement devoted to BEE-TEX
- Papers to discuss design and planning of study, along with very preliminary results
- More mature results reserved for atmospheric science journals with high impact factors
BEE-TEX Web Portal


• Graphic display of emission inventory at: http://maps.harc.edu/beetex/.

• Site planning for field study instruments (DOAS, mobile labs, lung cells) using a password-protected site: http://terra.harc.edu/test/milby/ .
What Will Happen Today?

• Presentations by major field study investigators
• Public discussion of BEE-TEX in preparation for deliberation of TERC Science Advisory Committee (SAC) tomorrow
• Lunch for invited guests
• Bus tour of field study sites:
  – Port of Houston Authority
  – Valero Refinery
  – Hartmann Park in Manchester
  – Houston Regional Monitoring (HRM) Site 1
  – Sidney Sherman (IH 610) Bridge
  – Clinton Drive CAMS
  – Galena Park CAMS
  – Milby Park CAMS
• Dinner for SAC and Research Team Members
Conclusion

• BEE-TEX will test new monitoring and modeling techniques that potentially yield more detailed and accurate information on ambient exposure to and source attribution of air toxics.

• BEE-TEX will benefit industry, regulators, and fence line communities by providing better tools for LDAR, permitting, and emissions reporting.

• TERC is willing to work collaboratively with all stakeholders to ensure the quality and success of the BEE-TEX campaign.