Delaware Community Air Toxics Studies

Delaware Department of Natural Resources and Environmental Control

Health Effects Workshop, Baltimore, MD
Betsy Frey
Nov. 7, 2008
Background

- Air toxics monitoring in Delaware began in the 1980’s
- Early studies focused on identifying compounds
- Subsequent efforts described concentrations and trends (ongoing)
- Current studies on spatial/temporal variation, source identification, and risk assessment
Delaware Air Toxics Assessment Study (DATAS) - 2003

- Characterize ambient concentrations (63 compounds) statewide
  - Used 5 existing monitoring locations
- Develop emissions inventory
- Risk assessment of ambient data (cancer and non-cancer risk)
- Use computer models to predict concentrations across entire state
DATAS Results

- **Monitoring Results**
  - Annual arithmetic mean of valid samples
  - Inter-site comparison of mean concentrations
  - Compare DATAS mean concentrations with the results of UATMP - Pilot Study

- **Major issues**
  - Appropriate statistics
  - Below MDL data, below MQL data
  - Data quality, confidence intervals
Intersite comparison – annual avgs

2003 1,3-Butadiene

- 1st Quartile
- Min.
- Median
- Max.
- 3rd Quartile

ppb

MLK  Lums  DC  Killens  Seaford
Compare with UATMP results

- Range of annual averages, lowest site to highest site
- Ann. Avg. from UATMP

- Formaldehyde
- Acetaldehyde
- Lead
- Nickel
- Manganese
- Chromium
- Cadmium
- Beryllium
- Arsenic

 ug/m³
Emissions Inventory

- Specific for Delaware, used NEI for surrounding states
- Used speciation profiles for VOCs and PM emissions
- Diesel as fraction of total on-road PM emissions
Example – 2003 Emissions VOCs

(Total 4871 tons)
DATAS Modeling – Two Applications

- Local-scale Modeling
  - For communities located near monitoring sites
- Regional-scale Modeling
  - Addresses emissions from all sources (point, area, mobile, biogenic)
  - Accounts for transport of pollutants from distant sources, atmospheric chemistry, and background concentrations
  - Monitoring data used for calibration of models to generate reliable predicted concentrations
Modeling Results:
Ambient Concentrations Benzene
Modeled Ambient Concentrations - Diesel Particulate Matter

Modeled Diesel Particulate Matter (PM) Concentrations in Delaware

Legend
- DE DATAS Monitor
- Major Roads
- County Boundary
- Water

Diesel PM
µg/m³
- 0.083 - 0.252
- 0.253 - 0.405
- 0.406 - 0.597
- 0.598 - 0.873
- 0.874 - 1.323
- 1.324 - 2.16
- 2.161 - 3.619
- 3.62 - 6.243
- 6.244 - 11.375
- 11.376 - 24.248

0 5 10 20 Kilometers
Division of Public Health

- DPH Environmental Health Evaluation Branch evaluated the health risk of exposure to DATAS chemicals at concentrations measured by DNREC.
- Risk estimates for monitoring data used mean values as calculated by DNREC.
Risk Assessment by DPH

- Receptor populations include adults, children, and combined child and adult exposures
- Child receptor most susceptible to non-cancer effects
- Results of risk assessment modeling stated as cumulative cancer and non-cancer risks for each site
DATAS – Risk Assessment
Calculations for each receptor population based on series of assumptions, generally taken directly from EPA publications.

- **Adult Resident calculations assume:**
  - 20 m$^3$/day inhalation rate
  - 70 Kg body weight (approx. 154 lbs)
  - 30 year exposure duration
  - 24 hours/day
  - 350 days/year exposure frequency
  - 70 year lifetime

- **Child resident calculations assume:**
  - 10 m$^3$/day inhalation rate
  - 15 Kg body weight (approx. 33 lbs)
  - 6 year exposure duration
  - 24 hours/day
  - 350 days/year exposure frequency
Risk Assessment Results

- Cancer risks stated as additional projected cancer cases per 100,000 exposed people
  - Risk of no more than 1 additional cancer case per 100,000 people = **GREEN.** (Acceptable Risk)
  - Risk of between 1 and 10 additional cancer cases per 100,000 people = **YELLOW.** (Increased Risk)
  - Risk of greater than 10 additional cancer cases per 100,000 people = **RED.** (High Risk)

- Similar analysis for non-cancer risk (acceptable, increased, high)
Risk Assessment Results

- Non-cancer risks are stated as hazard quotients representing risk of an adverse effect from exposure
  - Hazard quotient of no more than 1 are shown in **GREEN** (Low Risk)
  - Hazard quotient of between 1 and 10 are shown in **YELLOW** (Increased Risk)
  - Hazard quotient of more than 10 are shown in **RED** (High Risk)
Risk Results Summary

Cancer Risk

- Risk assessment results show that no single chemical of the 82 poses a risk greater than 1 additional cancer case per 100,000 exposed people near the sampling sites.

- Risk assessment results show that, when all chemicals are combined, cancer risk from each monitoring station showed an increased risk but did not exceed 5 additional cancer cases per 100,000 exposed people.
# Exposure to Each Individual Chemical – Risk Assessment for Cancer/5 Monitoring Sites

<table>
<thead>
<tr>
<th>Risk Scenarios</th>
<th>Martin Luther King Area Site</th>
<th>Delaware City Area Site</th>
<th>Lums Pond Area Site</th>
<th>Felton Area (Killens Pond) Site</th>
<th>Seaford Area Site</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Adult</strong></td>
<td>Less than 1 additional cancer case per 100,000 exposed people</td>
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</tr>
<tr>
<td><strong>Child</strong></td>
<td>Less than 1 additional cancer case per 100,000 exposed people</td>
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</tr>
<tr>
<td><strong>Age-adjusted (combination of adult and child)</strong></td>
<td>Less than 1 additional cancer case per 100,000 exposed people</td>
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**Legend**

- **High**: 10 or more additional cancer cases per 100,000 exposed people
- **Increased**: Greater than 1 but less than 10 additional cancer cases per 100,000 exposed people
- **Low**: 1 or less additional cancer cases per 100,000 exposed people
## Cumulative Risk Assessments for Cancer Cases
Exposure to All Chemicals/5 Monitoring Sites

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<tr>
<td><strong>Adult</strong></td>
<td>3.2 additional cancer cases per 100,000 exposed people</td>
<td>2.2 additional cancer cases per 100,000 exposed people</td>
<td>1.8 additional cancer cases per 100,000 exposed people</td>
<td>1.9 additional cancer cases per 100,000 exposed people</td>
<td>1.8 additional cancer cases per 100,000 exposed people</td>
</tr>
<tr>
<td><strong>Child</strong></td>
<td>1.4 additional cancer cases per 100,000 exposed people</td>
<td>Less than 1 additional cancer case per 100,000 exposed people</td>
<td>Less than 1 additional cancer case per 100,000 exposed people</td>
<td>Less than 1 additional cancer case per 100,000 exposed people</td>
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</tr>
<tr>
<td><strong>Age-adjusted</strong></td>
<td>4.4 additional cancer cases per 100,000 exposed people</td>
<td>3.5 additional cancer cases per 100,000 exposed people</td>
<td>2.6 additional cancer cases per 100,000 exposed people</td>
<td>2.7 additional cancer cases per 100,000 exposed people</td>
<td>2.5 additional cancer cases per 100,000 exposed people</td>
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### Legend
- **High**: 10 or more additional cancer cases per 100,000 exposed people
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- **Low**: 1 or less additional cancer cases per 100,000 exposed people
Risk Results Summary

Non-Cancer Risk

- Risk assessment results show that no single chemical poses more than a minimal adverse health effect to people near the sampling sites.

- Risk assessment results show that, when all chemicals are combined, adverse health effect levels for non-cancer at many monitoring station areas was greater than a hazard index of 1, but in all cases was less than 5.
# Exposure to Each Individual Chemical – Adverse Health Effect Level for Non-Cancer/5 Monitoring Sites

<table>
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<tr>
<th>Risk Scenarios</th>
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<th>Seaford Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult</td>
<td>Adverse health effect level of less than 1</td>
<td>Adverse health effect level of less than 1</td>
<td>Adverse health effect level of less than 1</td>
<td>Adverse health effect level of less than 1</td>
<td>Adverse health effect level of less than 1</td>
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<tr>
<td>Child</td>
<td>Adverse health effect level of less than 1</td>
<td>Adverse health effect level of less than 1</td>
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</table>

**Legend**

- **High**: Adverse health effect level of 10 or greater.
- **Increased**: Adverse health effect level greater than 1 but less than 10.
- **Low**: Adverse health effect level of 1 or less.
# Cumulative Adverse Health Effect Level for Non-Cancer Exposure to All Chemicals/5 Monitoring Sites

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</tr>
</thead>
<tbody>
<tr>
<td><strong>Adult</strong></td>
<td>Adverse health effect level of 1.2</td>
<td>Adverse health effect level less than 1</td>
<td>Adverse health effect level of less than 1</td>
<td>Adverse health effect level of less than 1</td>
<td>Adverse health effect level of less than 1</td>
</tr>
<tr>
<td><strong>Child</strong></td>
<td>Adverse health effect level of 2.6</td>
<td>Adverse health effect level of 1.4</td>
<td>Adverse health effect level of 1.4</td>
<td>Adverse health effect level of 1.3</td>
<td>Adverse health effect level of 1.3</td>
</tr>
<tr>
<td><strong>Age-adjusted (combination of adult and child)</strong></td>
<td>Adverse health effect level of 1.6</td>
<td>Adverse health effect level of less than 1</td>
<td>Adverse health effect level of less than 1</td>
<td>Adverse health effect level of less than 1</td>
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</tr>
</tbody>
</table>

**Legend**

- **High**: Adverse health effect level of 10 or greater.
- **Increased**: Adverse health effect level between greater than 1 but less than 10.
- **Low**: Adverse health effect level of 1 or less.
DATAS Conclusion:

- MLK Monitoring Site showed increased risk for all three receptor populations for compounds:

<table>
<thead>
<tr>
<th>Carcinogens</th>
<th>Non-Carcinogens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chromium (VI)</td>
<td>Manganese</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Carbon tetrachloride</td>
</tr>
<tr>
<td>Benzene</td>
<td>1,3-Butadiene</td>
</tr>
<tr>
<td>1,3-Butadiene</td>
<td>1,2,4-Trimethylbenzene</td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td></td>
</tr>
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</table>
## DATAS SIGNIFICANT CHEMICALS – Carcinogens

<table>
<thead>
<tr>
<th>Carcinogenic Chemicals</th>
<th>Sources</th>
<th>Human Health Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chromium VI</td>
<td>Point, mobile and area sources</td>
<td>Lung cancer. Respiratory effects include asthma and bronchitis.</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Area sources and point source</td>
<td>Lung, liver and kidney cancer. Central nervous system effects include headache, nausea and blurred vision</td>
</tr>
<tr>
<td>Chloroethene (Vinyl Chloride)</td>
<td>Point sources</td>
<td>Liver cancer</td>
</tr>
<tr>
<td>Benzene</td>
<td>Mobile sources</td>
<td>Leukemia Blood disorders, including aplastic anemia and excessive bleeding.</td>
</tr>
<tr>
<td>1,3-Butadiene</td>
<td>Mobile sources</td>
<td>Leukemia Blood disorders and Cardiovascular disease</td>
</tr>
<tr>
<td>Carbon Tetrachloride</td>
<td>No widespread sources</td>
<td>Liver cancer. Liver and kidney damage</td>
</tr>
</tbody>
</table>
# DATAS SIGNIFICANT CHEMICALS – Non-carcinogens

<table>
<thead>
<tr>
<th>Non-carcinogenic Chemicals</th>
<th>Sources</th>
<th>Non-carcinogenic Human Health Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese</td>
<td>Road dust and point sources</td>
<td>Respiratory effects such as bronchitis and increased susceptibility to infectious lung disease and nervous system effects</td>
</tr>
<tr>
<td>Carbon Tetrachloride</td>
<td>No widespread sources</td>
<td>Liver and kidney damage</td>
</tr>
<tr>
<td>1,3-Butadiene</td>
<td>Mobile sources</td>
<td>Cardiovascular disease and blood disorders</td>
</tr>
<tr>
<td>1,2,4-Trimethylbenzene</td>
<td>Mobile sources</td>
<td>Irritant, blood changes, nervous system effects</td>
</tr>
</tbody>
</table>
DATAS Remaining Tasks

- Phase II –
  - Model ambient air pollutant concentrations beyond monitoring locations *DONE*
  - Conduct risk assessment on modeled concentrations statewide *IN PROGRESS*

- Communicate the Phase II modeling and risk assessment results, establish long-term outreach priorities and air toxics reduction partnerships.
DATAS Issues/Lessons

- Monitoring
  - Methods, data handling/statistics (always consider final data use), data validation

- Emissions Inventory
  - Methods, data quality

- Modeling
  - Input data format/quality, resources/expertise

- Risk Assessment
  - Selection of acceptable/non-acceptable risk levels
  - Involvement of Division Public Health
Elevated risk in urban Wilmington basis for developing Community Air Toxics Study (CATS) proposal

- Evaluate temporal/spatial VOC distributions
- Method development – sorbent tubes (two hour duration, 12 tubes per 24-hour sampling period) with GC-MS analysis
- Model validation
- Community-level risk assessment
Monitoring Site Selection

- Modeled concentrations overlaid on GIS maps within the Wilmington area.
- Population density tracks and sensitive receptors such as schools and hospitals identified.
Map of Modeled Ambient Concentrations

Benzene Exposure Concentrations Around Wilmington

Legend
- 5km Box
- PM2.5 Monitors
- Private Schools
- Public Schools
- Hospitals
- Air Facilities

Benzene
μg/m³
- 0.202 - 0.376
- 0.377 - 0.491
- 0.492 - 0.621
- 0.622 - 0.809
- 0.81 - 1.085
- 1.086 - 1.489
- 1.49 - 2.262
- 2.263 - 3.735
- 3.736 - 6.421
- 6.422 - 15.392
Monitoring and Lab Analysis

*In Progress*

- 15 month study
- Sorbent tubes
  - 12-2 hour samples (temporal variation)
  - 1 in 6 day schedule
- 5 community sites, include 1 collocated + 1 background (spatial variation)
- Lab analysis – GC/MS
Future Data Analysis

Includes:

- Evaluate method (i.e., sorbent tubes for two-hour averages), temporal/spatial patterns
- Correlate multiple variables (meteorology, traffic patterns, emission inventory, etc.)
- Identify source contributions
- Compare with modeled outputs
- Risk assessment
DATAS and CATS contributors:

- Project oversight & coordination – Joe Martini
- Modeling – Mohammed Majeed
- Monitoring methodology – Jill Winterling
- Monitoring data analysis – Betsy Frey, Jack Sipple
- Community involvement – Terri Brixen
- Emissions Inventories – Dave Fees
- Risk Assessment (Division Public Health) – Jerry Llewellyn