

Ambient Acetaldehyde in the District of Columbia and Potential Health Risk

Abdullahi A. Asimalowo¹, Kofi Asante-Duah², Rama Seshu Tangirala¹

¹Monitoring and Assessment Branch, Air Quality Division, ²Environmental Protection Administration, District Department of the Environment, Washington, DC

National Air Toxics Monitoring and Data Analysis Workshop

April 4-7, 2011

US EPA Region 6, Dallas, TX



Acknowledgements

Authors would like to acknowledge the assistance from the Monitoring and Assessment Branch staff: Robert Day, Khin Sann Thaung, Richard Tun, Jessica Daniels, Winston Thaung, and others.

Disclaimer

This presentation and the opinions therein are those of the authors and do not necessarily represent or express the views of the District Department of the Environment or the Government of the District of Columbia

Objectives

- Evaluate the ambient acetaldehyde (CH_3CHO) levels in the District of Columbia.
 - Data period 2004-2009
- Assess potential human health related risk.

Overview

- Carbonyls are monitored in the District of Columbia (District) as part of the national air toxics trends stations (NATTS) monitoring network.
- NATA 2005 ranked aldehydes as high health risk compounds among ambient air toxics.
- Acetaldehyde (CH_3CHO) in the carbonyls group was selected for the preliminary study because of a high percent of data capture.

Overview...

Physical Properties

- Chemical formula: CH_3CHO
- Molecular weight: 44.06g/mol
- Colorless liquid; miscible with water
- Odor is pungent and suffocating
- Vapor pressure is 740 mmHg at 20°C

Overview...

Potential Health Concerns

- Cancer Risk
 - Classified as Group B: probable human carcinogen ^{1,3,5}
 - Limited information available ^{1,3}
 - High incidence of nasal tumors in rats and laryngeal tumors in hamsters have been noted ^{1,3}

Overview...

Potential Health Concerns

- Acute Exposure
 - Irritation of eyes, skin, and respiratory tract;
 - Erythema, coughing, pulmonary edema, and necrosis (at high exposure);
 - Depressed respiratory rate and elevated blood pressure in experimental animals.

» US DOHHS (1993); US EPA (1987)

Overview...

Potential Health Concerns

- Chronic (non-cancer)
 - Symptoms similar to alcoholism.
 - Reference concentration (RfC) is 0.009 mg/m³.
 - *‘At exposures increasingly greater than the RfC, the potential for adverse health effects increases.’*

US EPA (1999)

Overview...

Potential Health Concerns

- Reproductive/Developmental Effects
 - Animal studies indicate potential developmental effects.
 - Shown to cross placenta to fetus in animals (1,4).
 - Rats injected with CH_3CHO showed skeletal malfunction, lower birth weight, and higher postnatal mortality.
 - No information available for humans.

EPA, 1987; IARC, 1985

Overview...

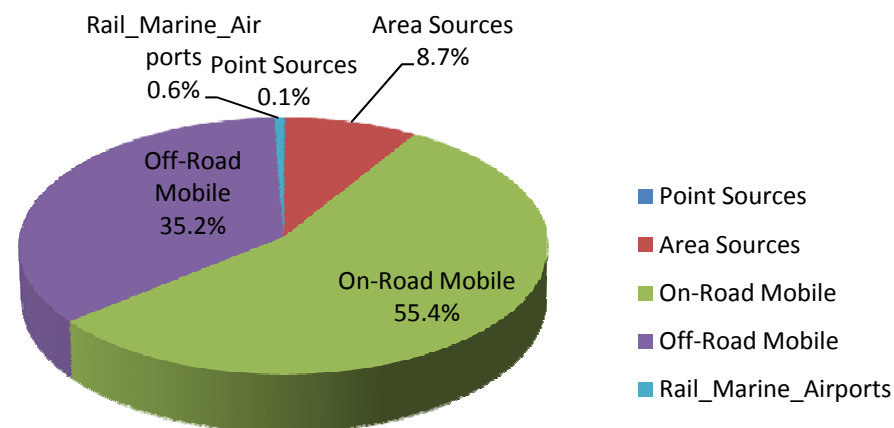
Potential Sources

- Vehicular exhaust fumes ^{1,2,3}
- Photochemical degradation of volatile organic compounds (VOCs) ^{1,2,3}
- Product of incomplete combustion in fire places ^{1,2,3}
- Higher plant respirations ^{4,6,,7}
- Coffee roasting ^{1,2,3}
- Tobacco burning ^{1,2,3}
- Coal refining ^{1,2,3}
- Waste processing ^{1,2,3}

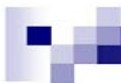
Overview...

Acetaldehyde Emissions in the District

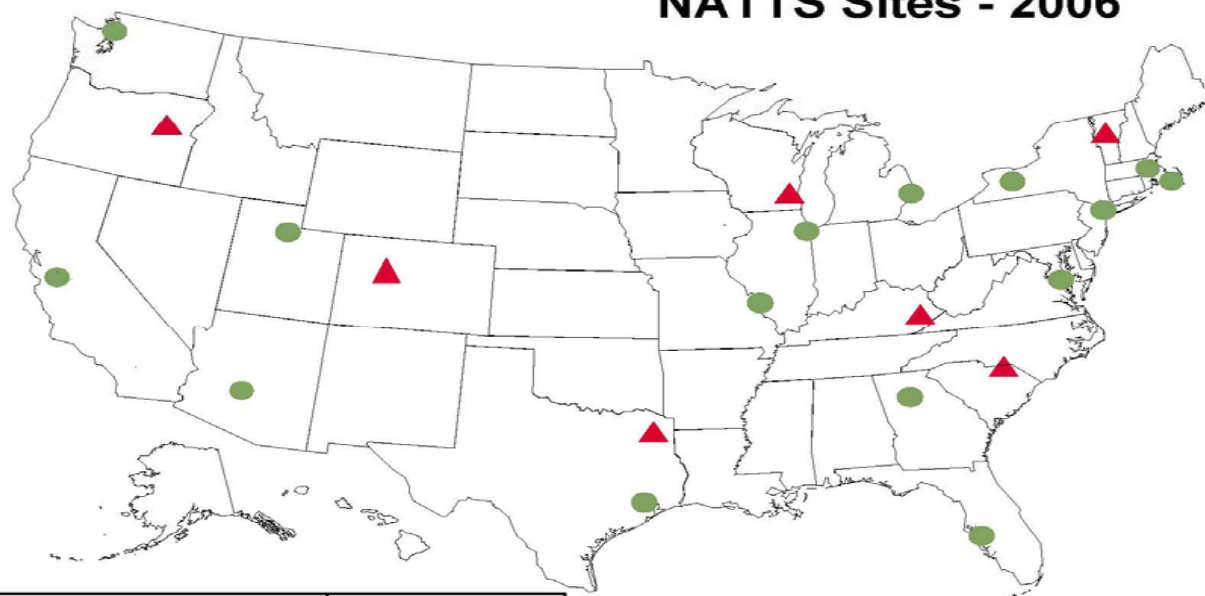
- 49.8 tons per year (Data source: 2005 NATA Inventories)
- Vehicular (on-road and off-road) exhaust is the primary source



Air Toxics Sampling and Analysis Method



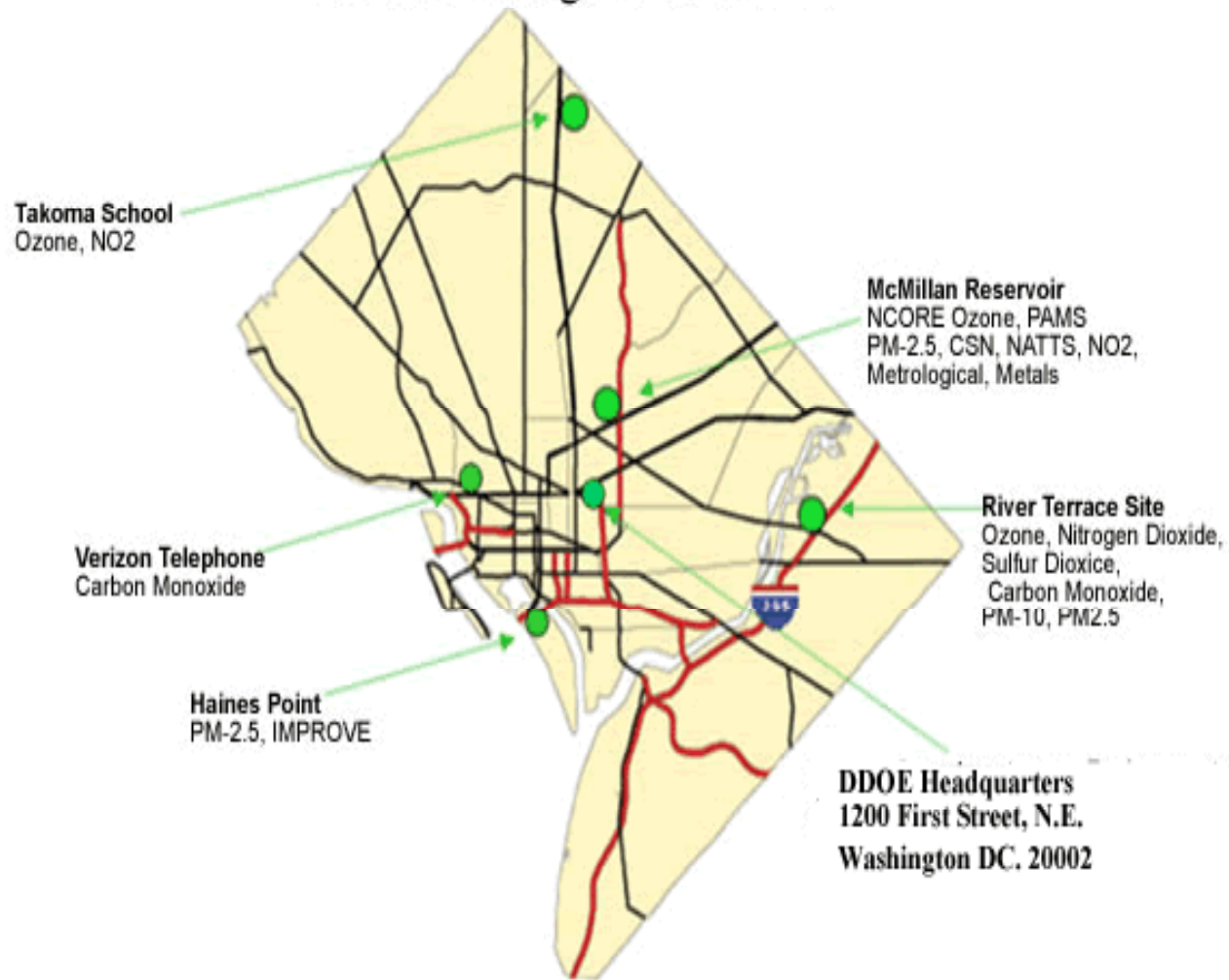
NATTS Sites - 2006



•Urban Sites		•Rural
•E. Providence, RI	•Chicago, IL	•Underhill, VT
•Boston (Roxbury), MA	•Houston (Deer Park), TX	•Hazard, KY
•New York, NY	•St. Louis, MO	•Chesterfield, SC
•Rochester, NY	•Bountiful, UT	•Mayville, WI
•Washington, DC	•San Jose, CA	•Grand Junction, CO
•Decatur, GA	•Phoenix, AZ	•La Grande, OR
•Tampa, FL	•Seattle WA	•Harrison County, TX
•Detroit, MI		

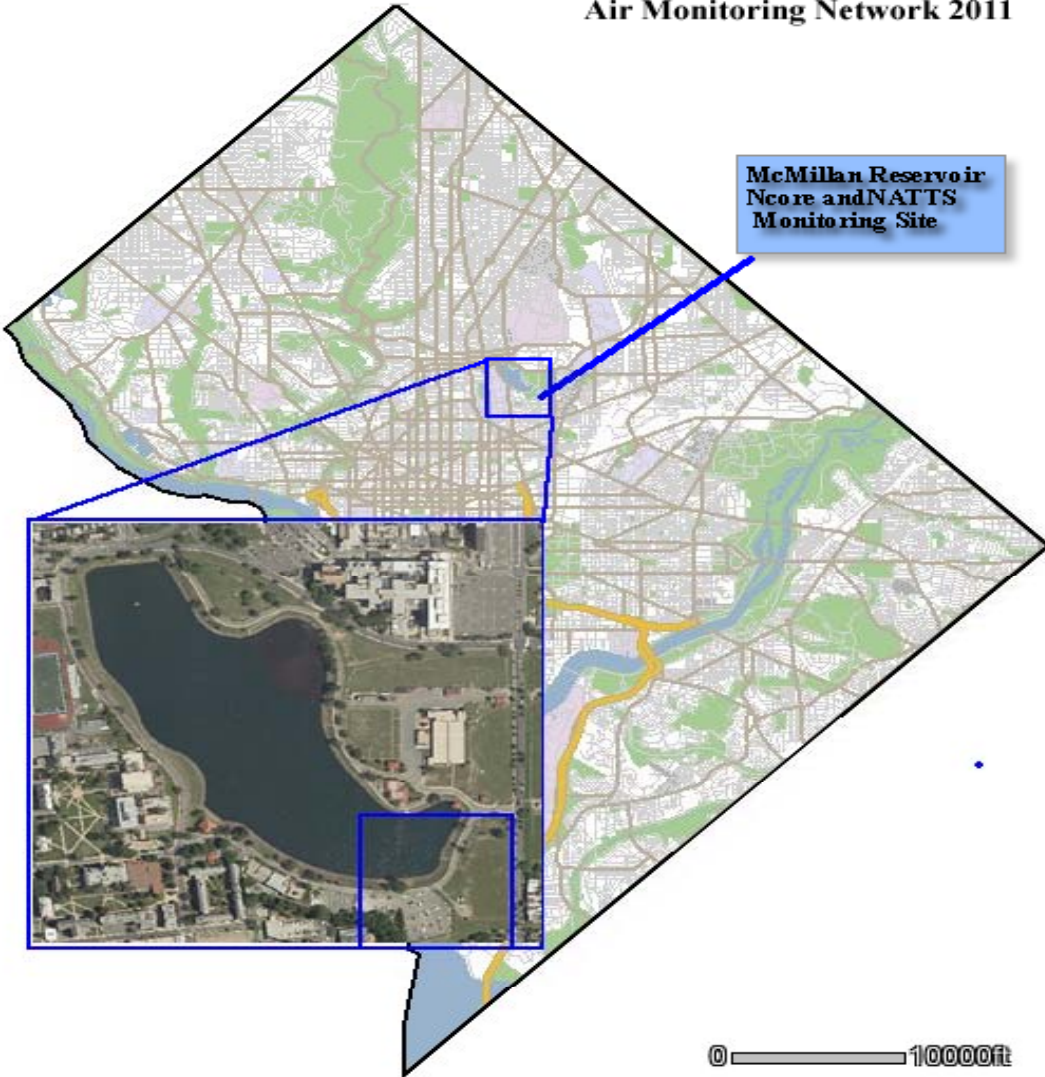


District of Columbia Department of the Environment Air Monitoring Network



McMillan Reservoir Station

District of Columbia
Air Monitoring Network 2011



McMillan Reservoir Air Monitoring Station

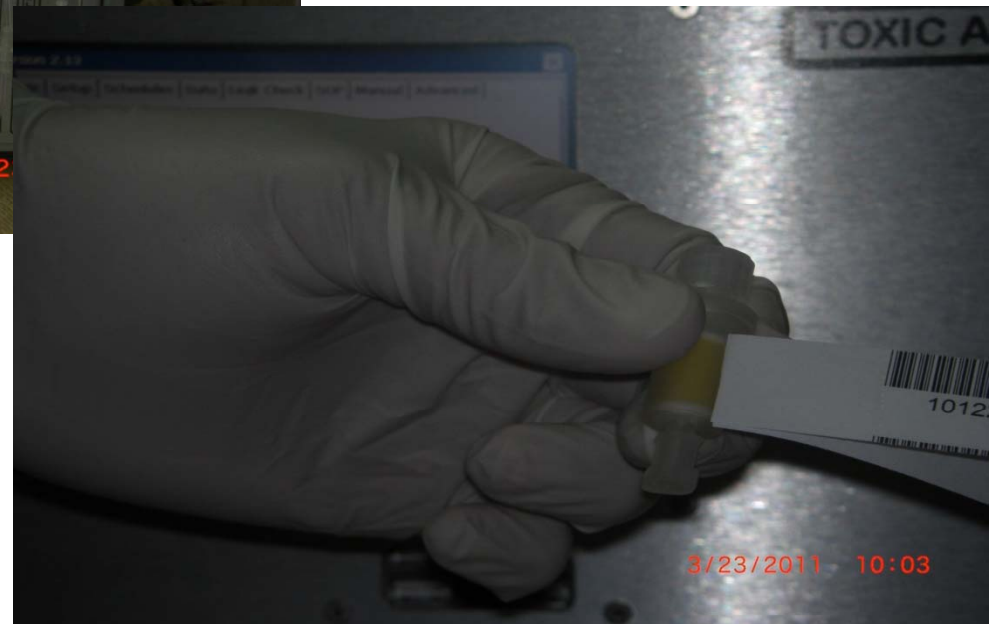


Sampling and Analysis Method

Samples are collected and analyzed using EPA's Compendium Method TO-11A (Compendium of Methods for Determination of Toxic Organic Compounds in Ambient Air).

- Samples are collected using adsorbent cartridge 2,4-dinitrophenylhydrazine (DNPH) on silica.
- 24-hour sampling once every six days.
- District's samples are sent to Philadelphia AMS laboratory for analysis.

Sampling Instrument



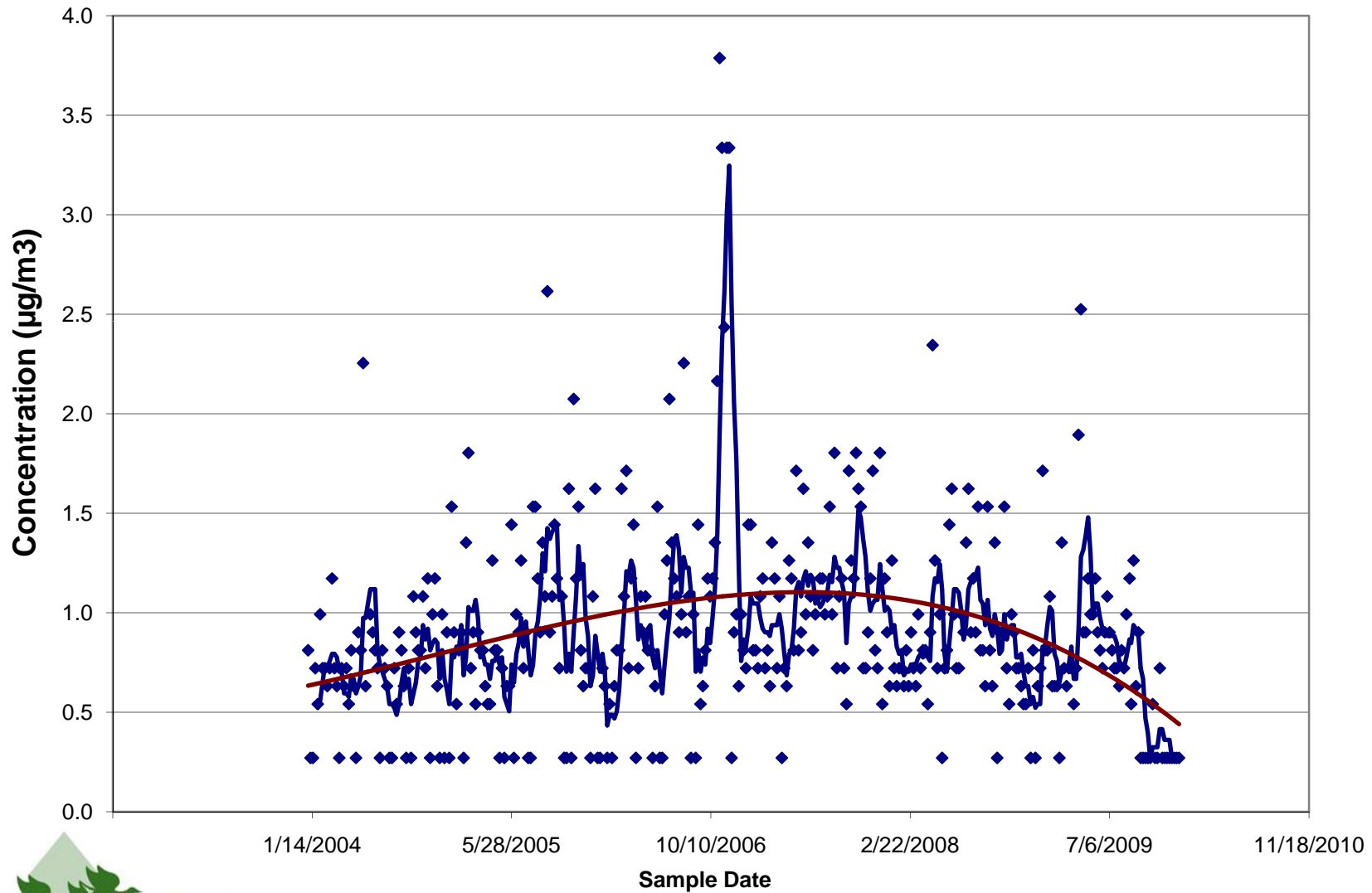
Sampling and Analysis Method...

- EPA Compendium Method TO-11A
 - Analyzed using High Performance Liquid Chromatography (HPLC).
 - Data posted on the EPA's data repository, Air Quality Systems (AQS).
 - Data downloaded from AQS used in this study.

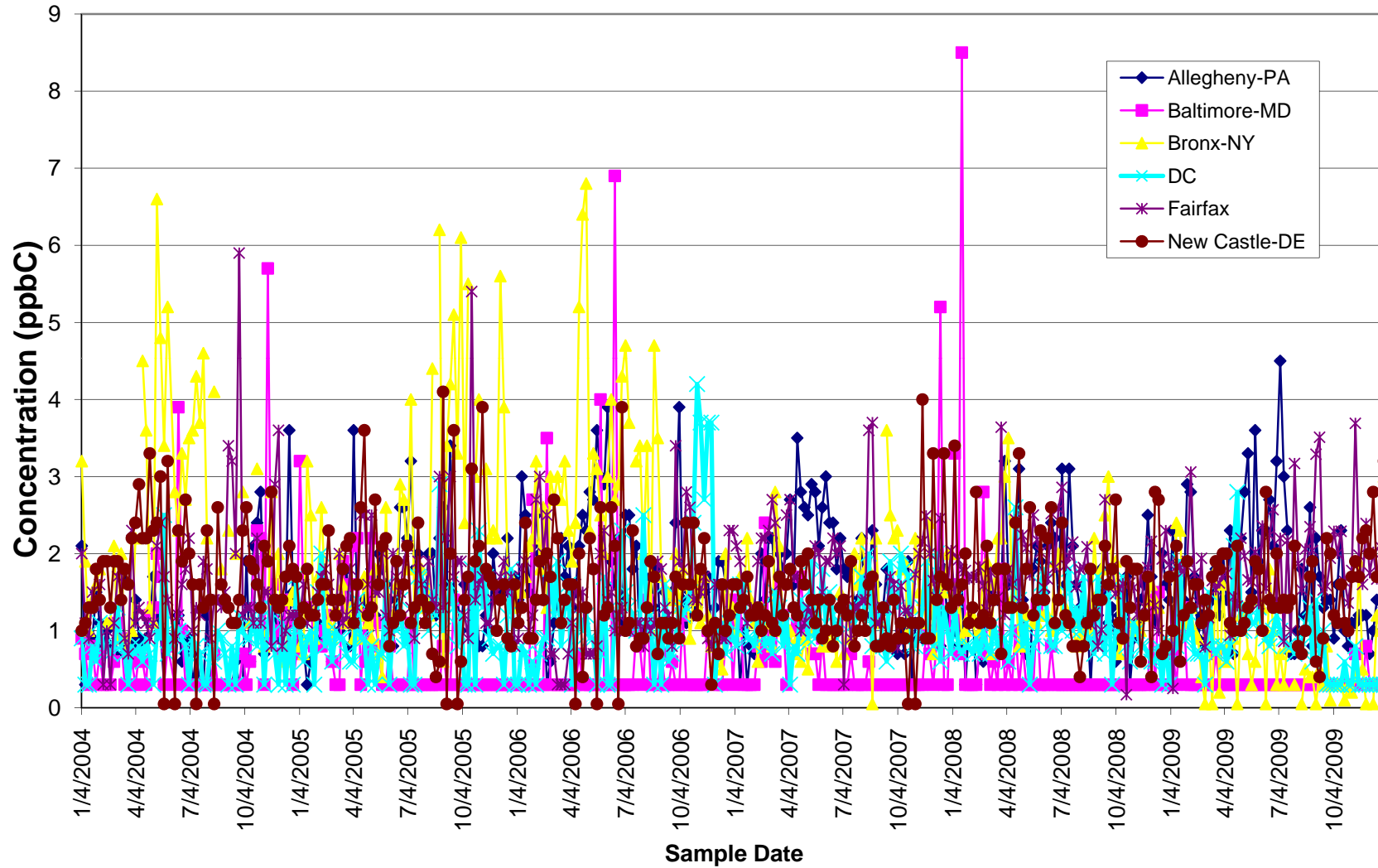
Data Analysis

- Data from 2004 to 2009 from the District's NATTS site analyzed.
- Number of yearly sampling events ranged between 59 and 61, indicating more than 98% data capture.
- Except 2009, all years had at least 70% of the samples above the method detection limit (MDL-0.6 ppbC).
- Overall, about 20% of the data were below the MDL.

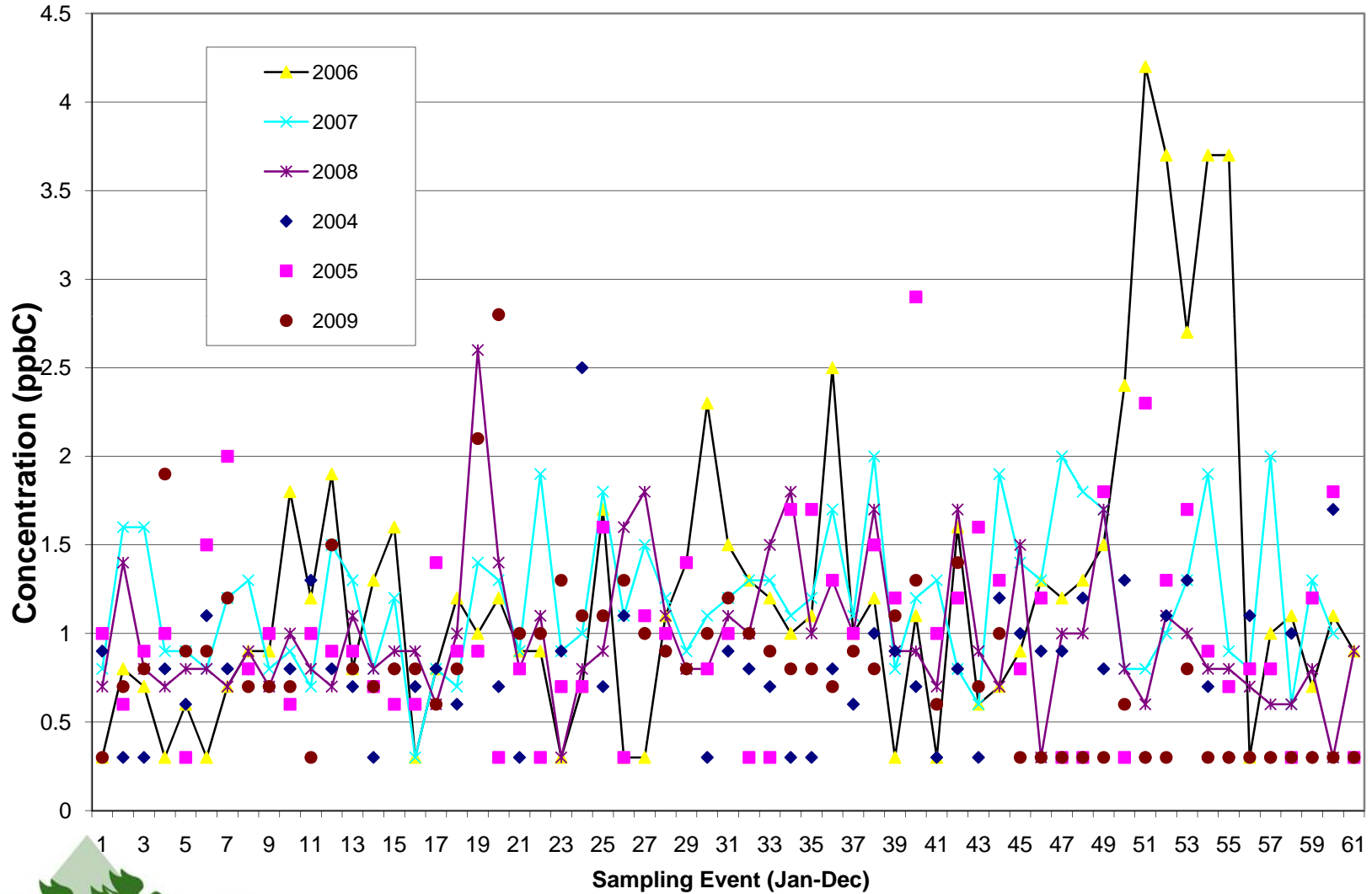
Ambient Acetaldehyde in the District of Columbia - 2004-2009 ($\mu\text{g}/\text{m}^3$)



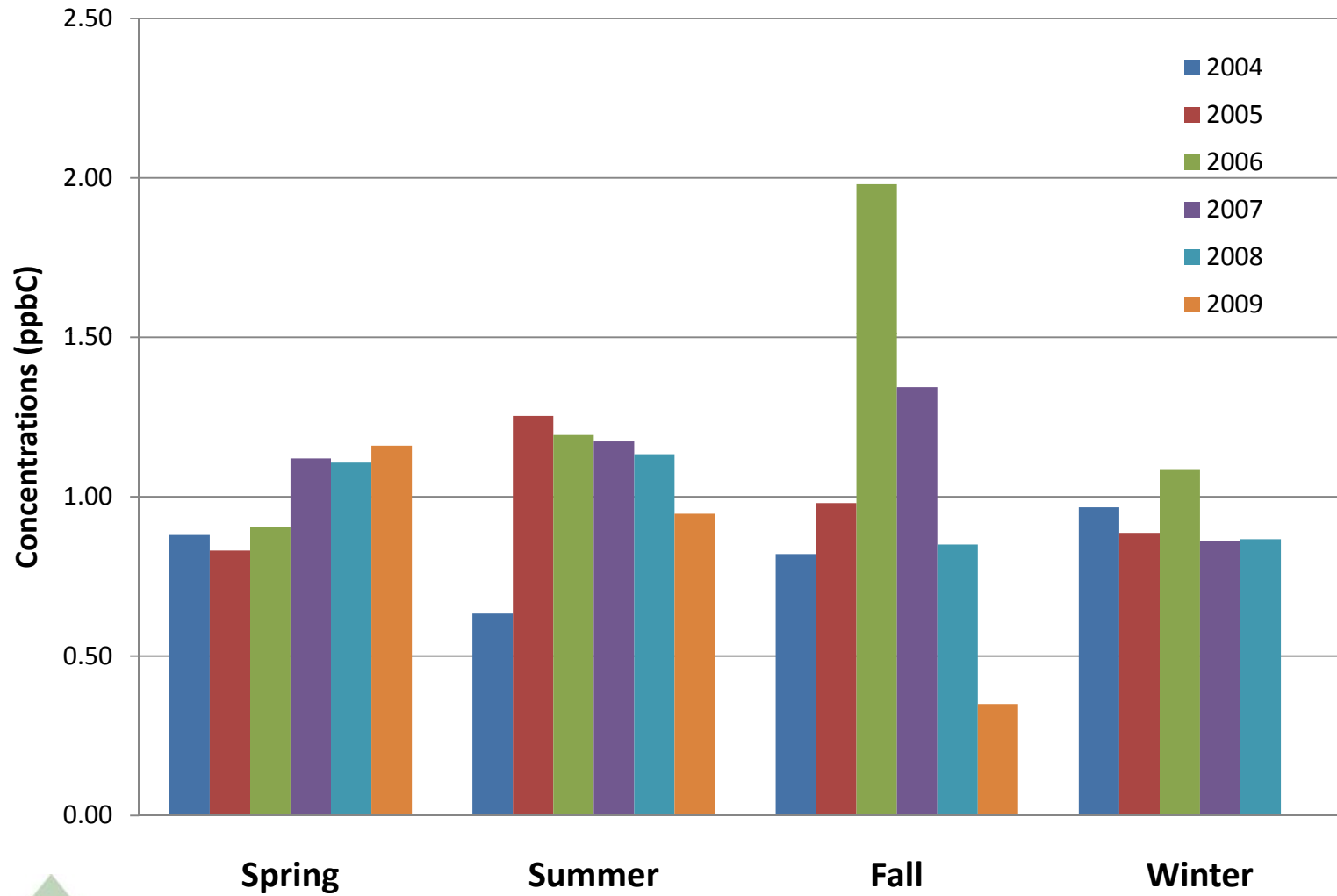
Acetaldehyde Concentrations at Select Locations in the Northeast



Acetaldehyde Concentrations in the District of Columbia - 2004-2009



Acetaldehyde Levels in the District of Columbia Seasonal Variation 2004-2009



Results and Discussion

- Annual Average concentrations:
 - Lowest in 2004
 - Mean: $0.72 \mu\text{g}/\text{m}^3$ and $\sigma=0.35$
 - Highest in 2006
 - Mean: $1.12 \mu\text{g}/\text{m}^3$ and $\sigma=0.80$
- No seasonality observed during the study period.

Any Potential Health Risk?

Results and Discussion: Potential Health Risk

Cancer risk

- Approximately 2 in a million.

Hazard Quotient (HQ)

- HQ for the six-year period estimated at 0.1.
- HQ is well below the risk threshold 1.

Conclusions

- No seasonal variation observed.
- 2 in a million cancer risk.
- HQ is low.
- Two years - 2006 and 2007, indicated slightly higher ambient levels than the other years.

Further Analysis and Recommendations

- The entire carbonyl family needs to be reviewed to determine population exposure concentrations.
- Source apportionment study may help explain contributions from various sources.
- Combining outdoor with indoor concentrations may better explain inhalation exposure.
- 2 in a million cancer risk calls for further review by accounting for other exposure sources.

References

1. U.S. Environmental Protection Agency. *Health Assessment Document for Acetaldehyde*. EPA/600/8-86-015A. Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Office of Research and Development, Research Triangle Park, NC. 1987.
2. U.S. Department of Health and Human Services. Registry of Toxic Effects of Chemical Substances (RTECS, online database). National Toxicology Information Program, National Library of Medicine, Bethesda, MD. 1993.
3. U.S. Environmental Protection Agency. [*Integrated Risk Information System \(IRIS\) on Acetaldehyde*](#). National Center for Environmental Assessment, Office of Research and Development, Washington, D.C. 1999.
4. Millet, D. B., Guenther, A., Siegel, D. A., Nelson, N. B., Singh, H. B., de Gouw, J. A., Warneke, C., Williams, J., Eerdekens, G., Sinha, V., Karl, T., Flocke, F., Apel, E., Riemer, D. D., Palmer, P. I., and Barkley, M.: Global atmospheric budget of acetaldehyde: 3-D model analysis and constraints from in-situ and satellite observations, *Atmos. Chem. Phys.*, 10, 3405-3425, doi:10.5194/acp-10-3405-2010, 2010.
5. International Agency for Research on Cancer (IARC). *IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans: Alkyl Compounds, Aldehydes, Epoxides and Peroxides*. Volume 36. World Health Organization, Lyon. 1985.
6. Jürgen Kreuzwieser, Cristian Cojocariu, Vera Jüssen and Heinz Rennenberg: Elevated Atmospheric CO₂ Causes Seasonal Changes in Carbonyl Emissions from *Quercus ilex*. *New Phytologist* Vol. 154, No. 2 (May, 2002), pp. 327-333
7. COJOCARIU, C., ESCHER, P., HÄBERLE, K.-H., MATYSSEK, R., RENNENBERG, H. and KREUZWIESER, J. (2005), The effect of ozone on the emission of carbonyls from leaves of adult *Fagus sylvatica*. *Plant, Cell & Environment*, 28: 603–611. doi: 10.1111/j.1365-3040.2005.01305.x