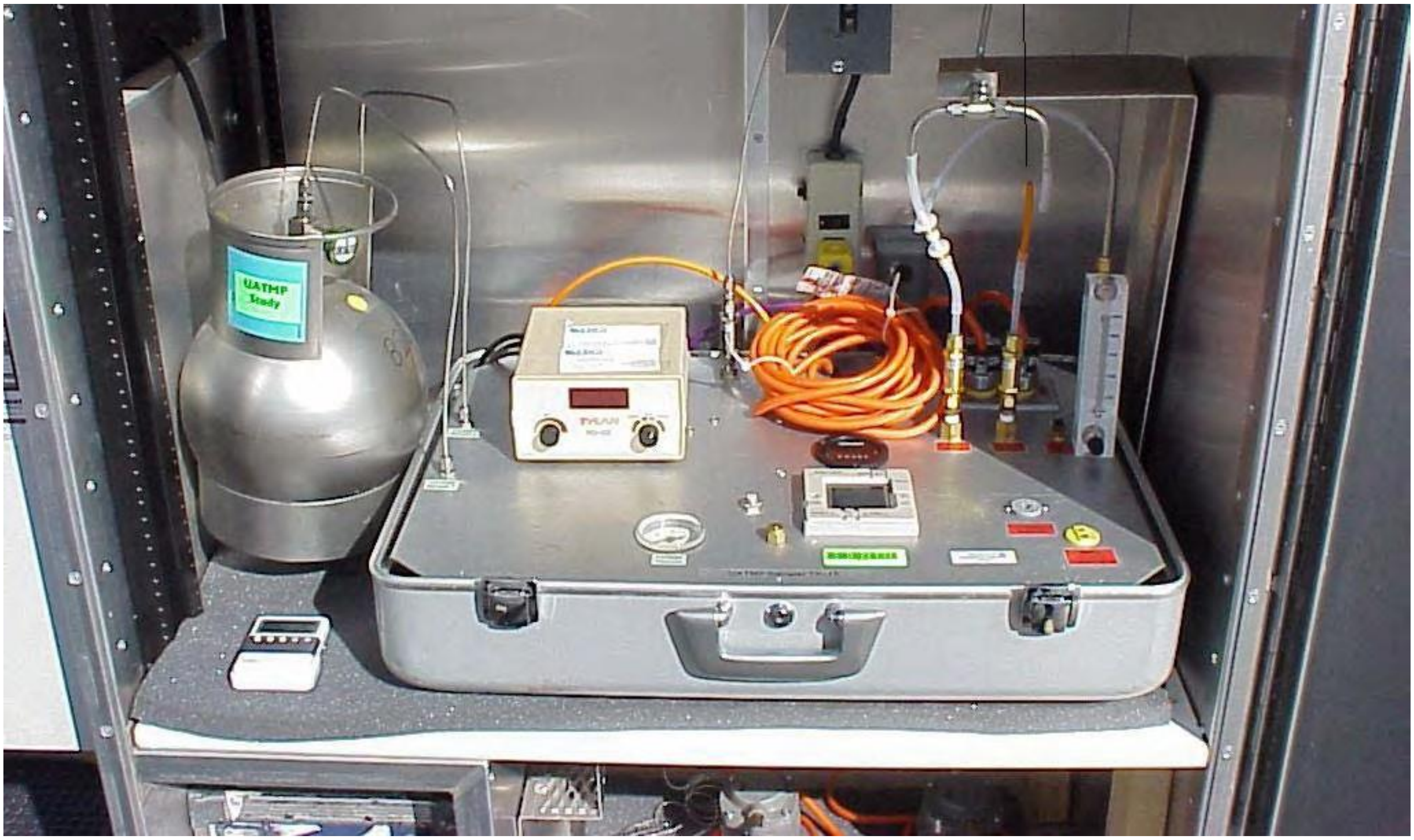
Iowa Toxics Sampling 2007
Results for Benzene, Acetaldehyde, and Formaldehyde



Air Quality Bureau
Iowa Department of Natural Resources

Table of Contents

Scope

Section 112 of the Clean Air Act [1] contains the federal strategy for protecting the public from air toxics emissions. The Act specifies a particular list of air toxics called "hazardous air pollutants" (HAPs) for regulatory action [2]. Emitters of large amounts of these HAPs are subject to regulations that require adoption of work practices or installation of control technologies in order to reduce HAP emissions [3]. The Act requires a periodic assessment of the residual health risk posed by the HAPs [4] and adoption of additional control standards where necessary [5].

In order to establish long term trends in HAP concentrations across the nation as a component of its residual risk assessment, EPA has funded national air toxics trends stations (NATTS) [6]. These sites contain a standard suite of samplers and analytical protocols [7]. Unlike NATTS sites, Iowa's air toxics sites do not have instrumentation to measure toxic metals, polycyclic aromatic hydrocarbons, or black carbon.

A review of the historical air toxics monitoring dataset [7] argues that benzene, formaldehyde, 1,3-butadiene, acrolein, arsenic, hexavalent chromium and diesel particulate pose the greatest risk to the public health on a national level. Only two of the seven national risk drivers are quantified by the limited air toxics sampling currently conducted in Iowa.

Sampling Schedules

Samples were gathered on a schedule of one sample every twelfth day. Every sixth day monitoring for carbonyl compounds was conducted during the ozone season (April through October). If a scheduled sample was missed, an unscheduled sample was substituted for the missing data point if that sample was taken before the next scheduled sampling day. In calculations of average pollutant levels and cancer risk the additional samples that were taken during summer time were averaged to estimate a one in twelve sampling schedule and avoid introduction of a seasonal bias to the data.

Data Capture

The data capture rate is defined as the ratio of the number of samples taken (including scheduled and valid substitute samples) divided by the number of scheduled samples.

Data Handling

This report characterizes only the cancer risk associated with exposure to the toxic contaminants measured, and does not quantify other "non-cancer" risks such as neurological or reproductive damage associated with the measured exposure levels. The cancer risk associated with a given exposure level was quantified only when an Air Unit Cancer Risk was available in EPA's Integrated Risk Information System (IRIS) database. Pollutants were selected for inclusion in this report, based on the screening criteria that the excess cancer risk resulting from a lifetime exposure to the average contaminant concentration measured was greater than the EPA benchmark of one in a million excess risks. When calculating the cancer risks and annual summary statistics for the selected pollutants, reported data values less than the method detection limit (MDL) are replaced with data values equal to half the MDL. Only Benzene had reported values under the MDL in 2007.

Precision Data

Precision data are reported for the total number of collocated pairs of canisters or cartridges collected. Precision statistics shown in this report have been calculated according to 40 CFR Part 58, Appendix A (2006) using the methodology applicable to collocated fine particulate data pairs.

Results of the Analysis

Formaldehyde, acetaldehyde, and benzene were measured at levels above the EPA benchmark at all Iowa sites. Formaldehyde levels measured during the study period are associated with a much higher cancer risk than any other pollutant measured in this study.

IRIS specifies different levels of certainty associated with its cancer risk factors. Benzene is classified as a known human carcinogen (Class A). Formaldehyde is a Class B1 carcinogen, and acetaldehyde is classified as a Class B2 carcinogen. Class B contains probable human carcinogens; Class B1 pollutants are associated with limited evidence of carcinogenicity in humans but sufficient evidence of carcinogenicity in animals, whereas a B2 classification indicates only sufficient evidence of carcinogenicity in animals [8].

A primary contaminant is directly emitted into the ambient air from its source. A secondary contaminant is formed from a chemical reaction of other contaminants already present in the atmosphere from natural or anthropogenic sources.

Benzene is a primary contaminant, with emissions largely attributed to vehicular traffic. Formaldehyde and acetaldehyde are both primary and secondary contaminants. Motor vehicle emissions contribute to primary emissions by incomplete combustion of fuel; secondary formation results from photochemical oxidation of exhaust pipe pollutants. Secondary formation of these pollutants is enhanced in the summertime due to suitable weather conditions such as higher temperature and greater hours of sunlight. Formaldehyde is also produced in large quantities by natural events such as forest or brushfires [10]. In interpreting the results of risk assessment contained in this type of report, EPA has encouraged States to compare the risks caused by toxic outdoor air pollution to other risks experienced in everyday life. The highest excess lifetime cancer risk identified in this report is 3.3 excess cancers per 100,000 people (3.3×10^{-5}), associated with average measured formaldehyde levels in the outdoor air at the urban Cedar Rapids and Des Moines monitoring sites. For comparison, the lifetime risk of dying in a car accident is a 4.2×10^{-3}, or approximately 127 times higher, and the lifetime risk of being killed by lightning is 1.3×10^{-5}, or approximately 2.5 times less than developing cancer at this level of formaldehyde exposure [11].

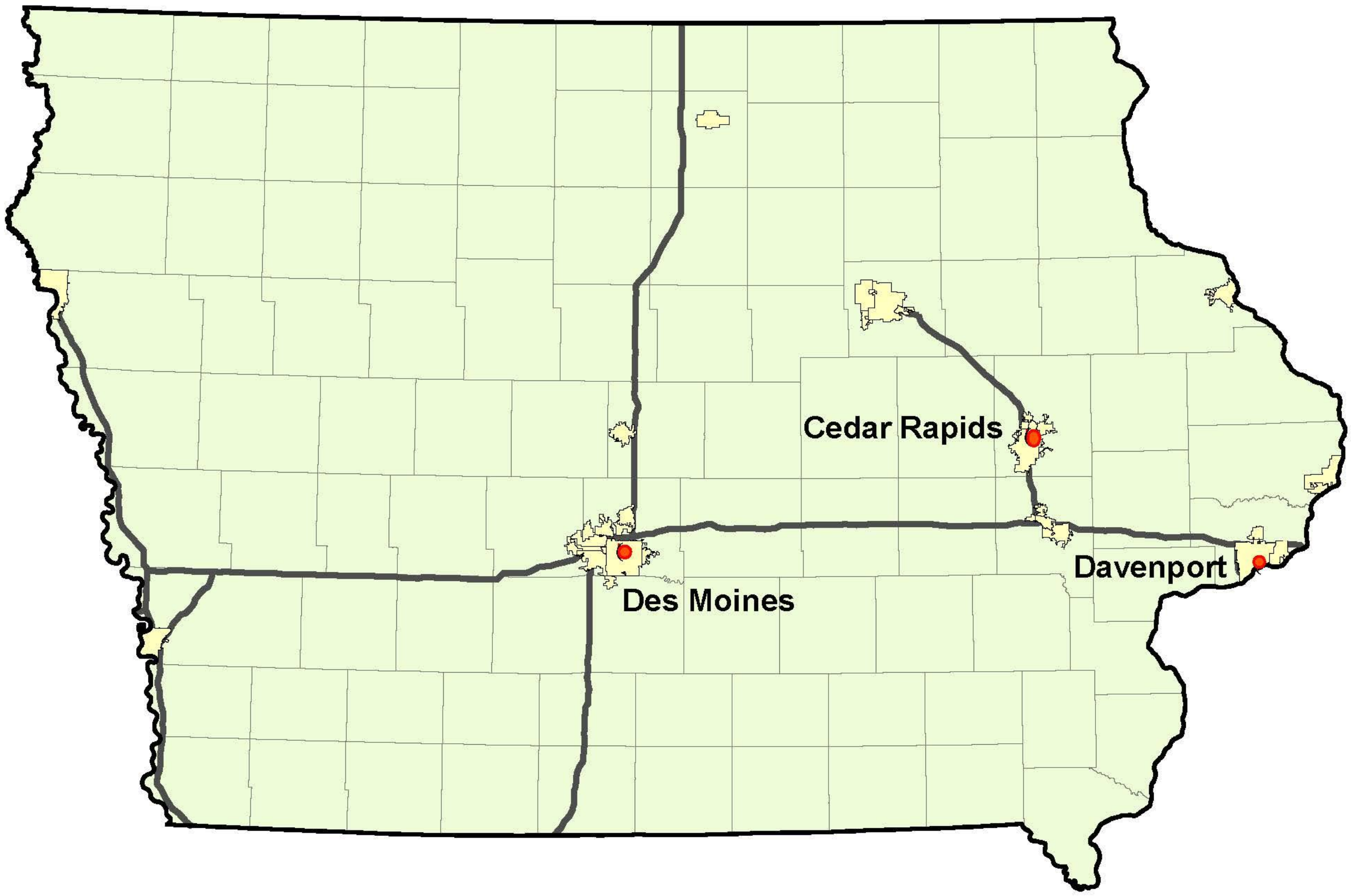
References:

1. Federal rules regulating air toxics: http://www.epa.gov/ttn/atw/eparules.html
2. Current list of HAPs and their health effects: http://www.epa.gov/ttn/atw/hlthef/hapindex.html
3. EPA regulations limiting HAPs emissions: http://www.epa.gov/ttn/atw/mactfnlalph.html
4. EPA's latest national assessment of the health risks due to HAPs: http://www.epa.gov/ttn/atw/natamain/
5. Residual risk assessments: http://www.epa.gov/ttn/atw/rrisk/rtrpg.html
6. Current list of NATTS sites: http://www.epa.gov/ttn/amtic/files/ambient/airtox/nattsite.pdf
7. Sampling protocol used to operate NATTS sites: http://www.epa.gov/ttn/amtic/files/ambient/airtox/nattsqapp.pdf
8. Historical review of air toxics monitoring data: http://www.ladco.org/toxics/reports/white%20paper%20phase%203/Phase%203%20WhitePaper.pdf
9. Integrated Risk Information System: http://www.epa.gov/iris
10. Canada EPA: http://www.ec.gc.ca/
11. Mortality Odds: http://www.nsc.org/lrs/statinfo/odds.html

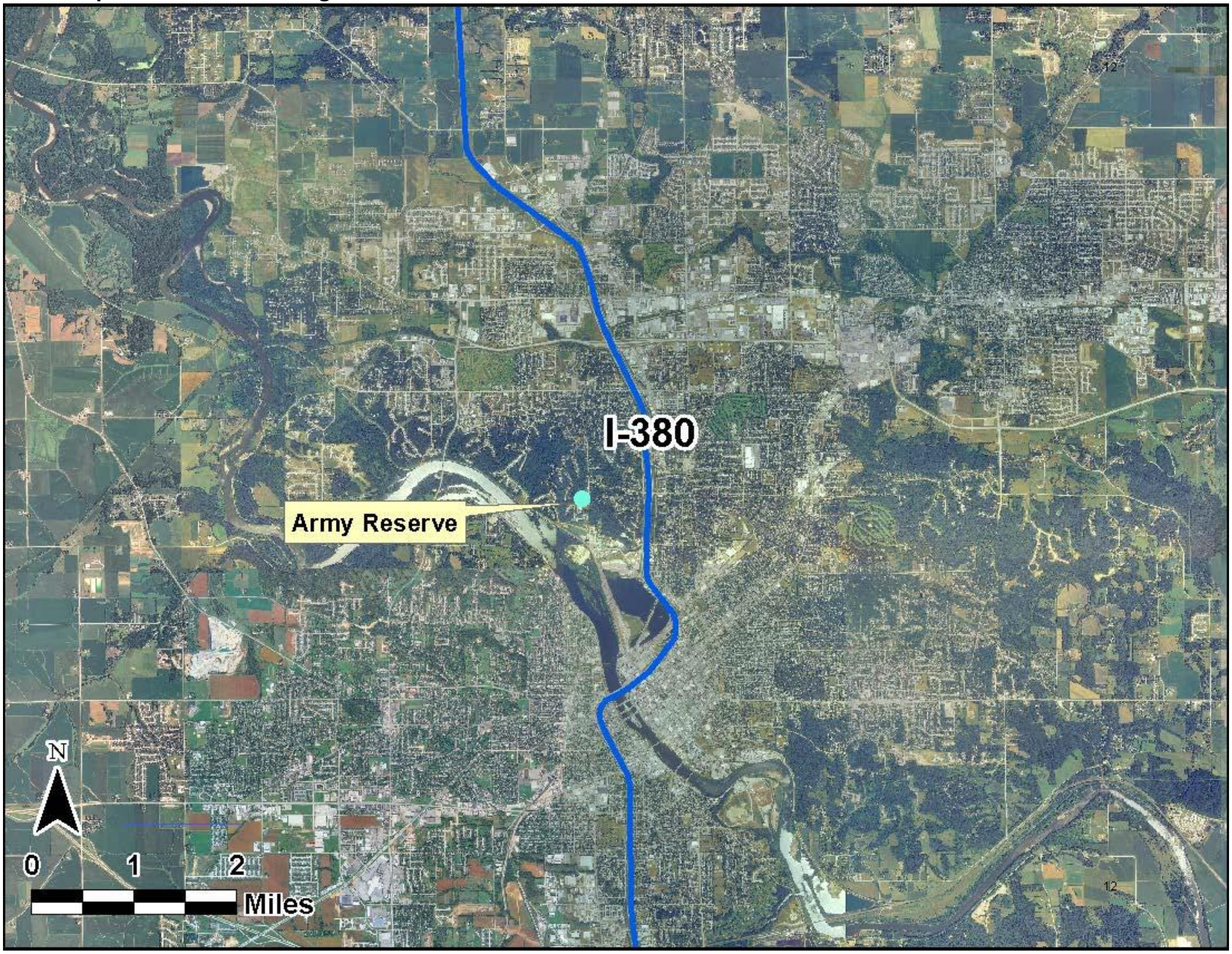
Air Toxics Monitoring Network 2007

Site ID	Site Label	City	Address	County
191130037	Cedar Rapids, Army Reserve	Cedar Rapids	1599 Wenig Rd. NE	Linn
191530030	Des Moines, Public Health Bldg	Des Moines	1907 Carpenter Ave.	Polk
191630015	Davenport, Jefferson Elementary	Davenport	10th St. & Vine St.	Scott

Iowa Toxics Monitoring Network 2007



Cedar Rapids Toxics Monitoring Site



Davenport Toxics Monitoring Site

Des Moines Toxic Monitoring Site

Cancer Risk Summary (Excess Cancers Per Million People)

Site / Pollutant	Cedar Rapids Army Reserve	Des Moines Public Health Building	Davenport Jefferson Elementary
Formaldehyde	33.1	32.8	32.1
Acetaldehyde	3.2	2.8	2.9
Benzene*	3.3	5.7	5.2

*IRIS lists two cancer risk estimates for Benzene, and the higher risk estimate is used for the statistics in this report.

Concentration Summary (ppb)

Site / Pollutant	Cedar Rapids Army Reserve	Des Moines Public Health Building	Davenport Jefferson Elementary
Formaldehyde	2.16 (+/- 0.29)	2.14 (+/- 0.36)	2.09 (+/- 0.32)
Acetaldehyde	0.90 (+/- 0.10)	0.78 (+/- 0.07)	0.80 (+/- 0.10)
Benzene	0.14 (+/- 0.04)	0.23 (+/- 0.05)	0.21 (+/- 0.05)

Note: value indicated are the average concentrations in parts per billion measured at each site in 2007. Data from enhanced summer monitoring at the three sites were averaged to prevent seasonal bias. Values listed in parentheses represent the 95% Confidence Interval for the mean.

Percent Data Capture

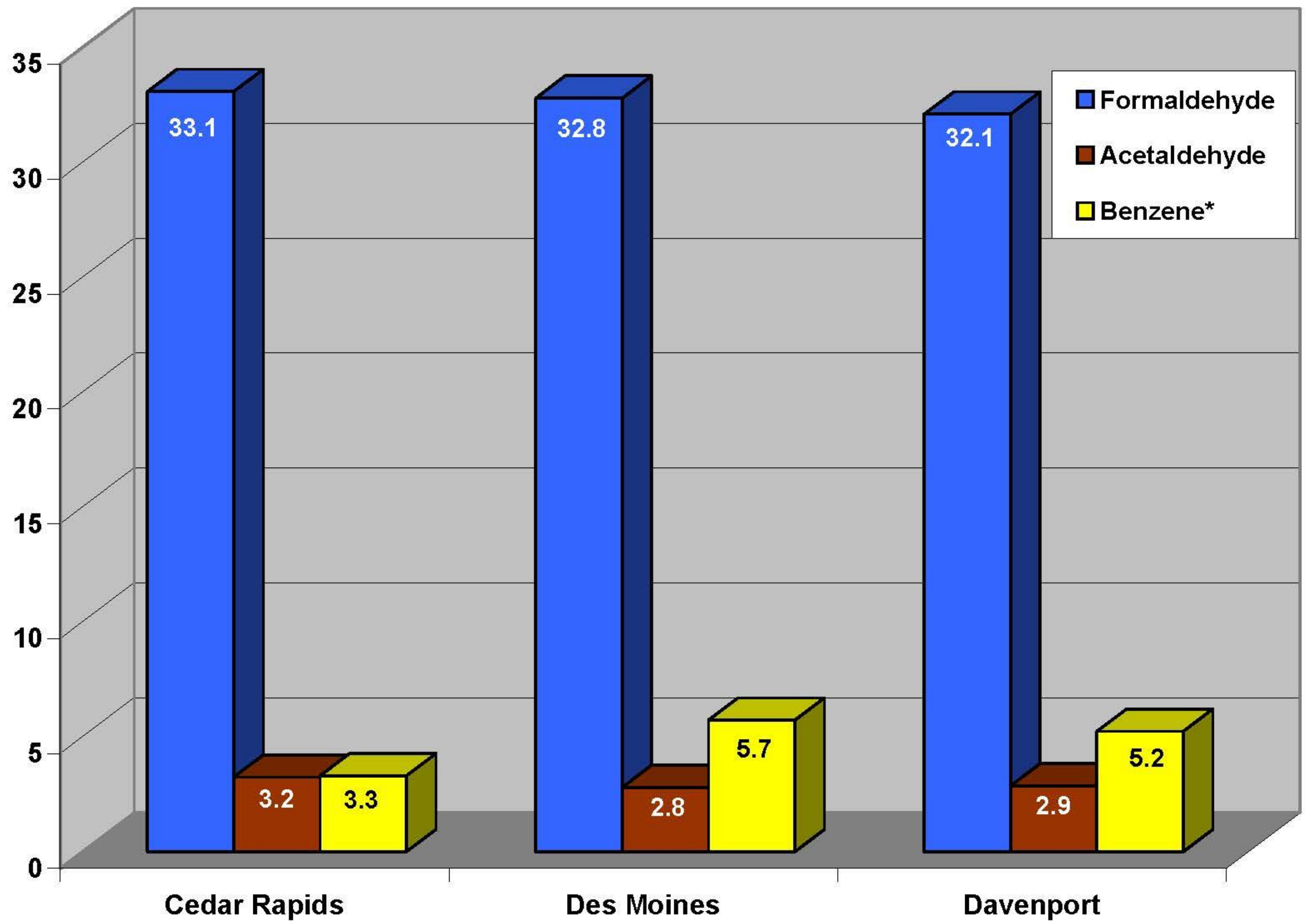
Site / Pollutant	Cedar Rapids Army Reserve	Des Moines Public Health Building	Davenport Jefferson Elementary
Formaldehyde	92%	90%	96%
Acetaldehyde	92%	90%	96%
Benzene	87%	93%	97%

Annual Toxics Precision Statistics

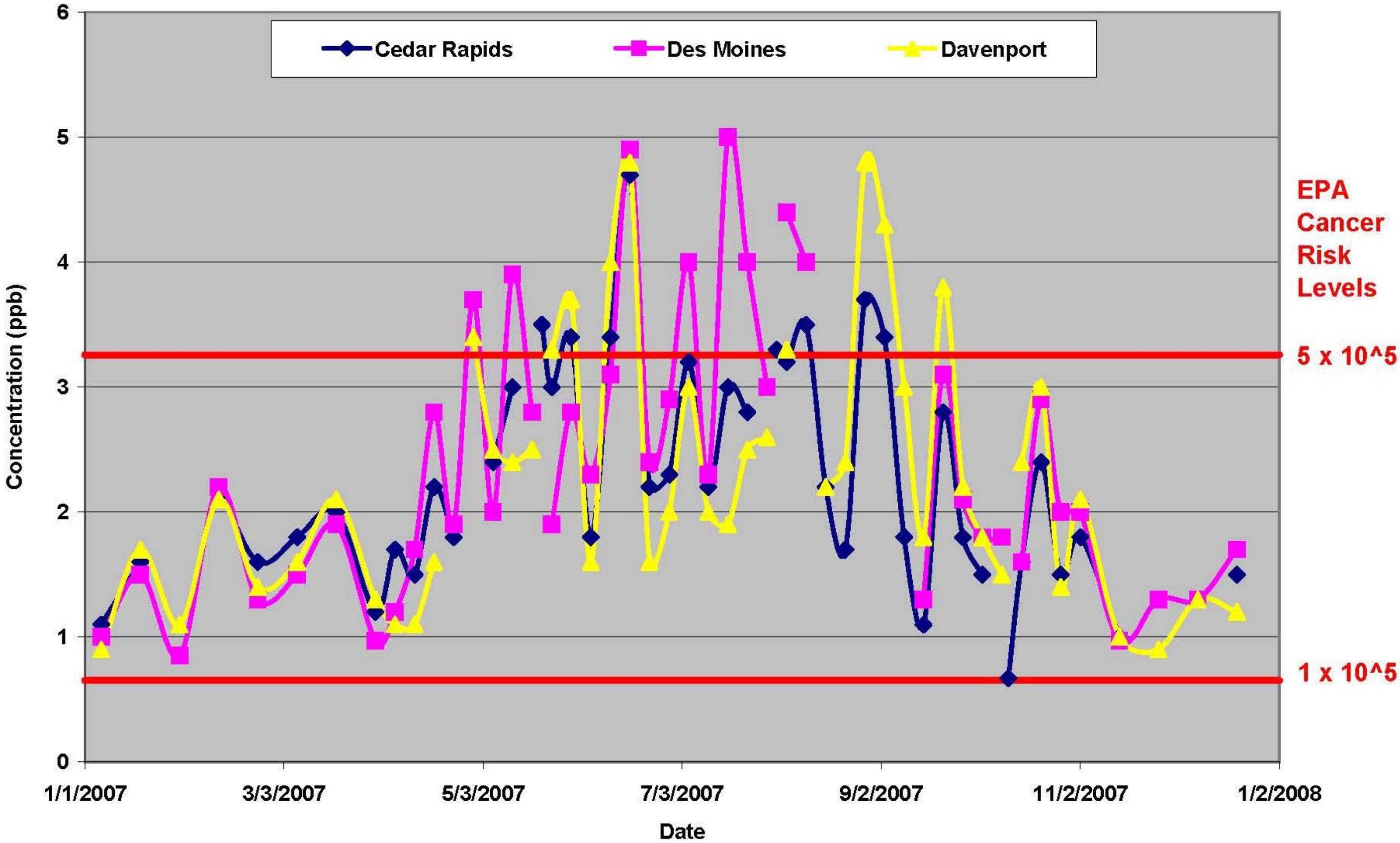
Statistic/ Pollutant	Number of Pairs	Coefficient of Variation	Lower 95% Confidence Limit	Upper 95% Confidence Limit
Formaldehyde	40	2.7%	2.3%	3.3%
Acetaldehyde	40	2.5%	2.1%	3.1%
Benzene	15	21.4%	16.6%	30.7%

Note: Statistics generated from collocated sample pairs. CV and confidence limits calculated according to 2006 methods in Appendix A.

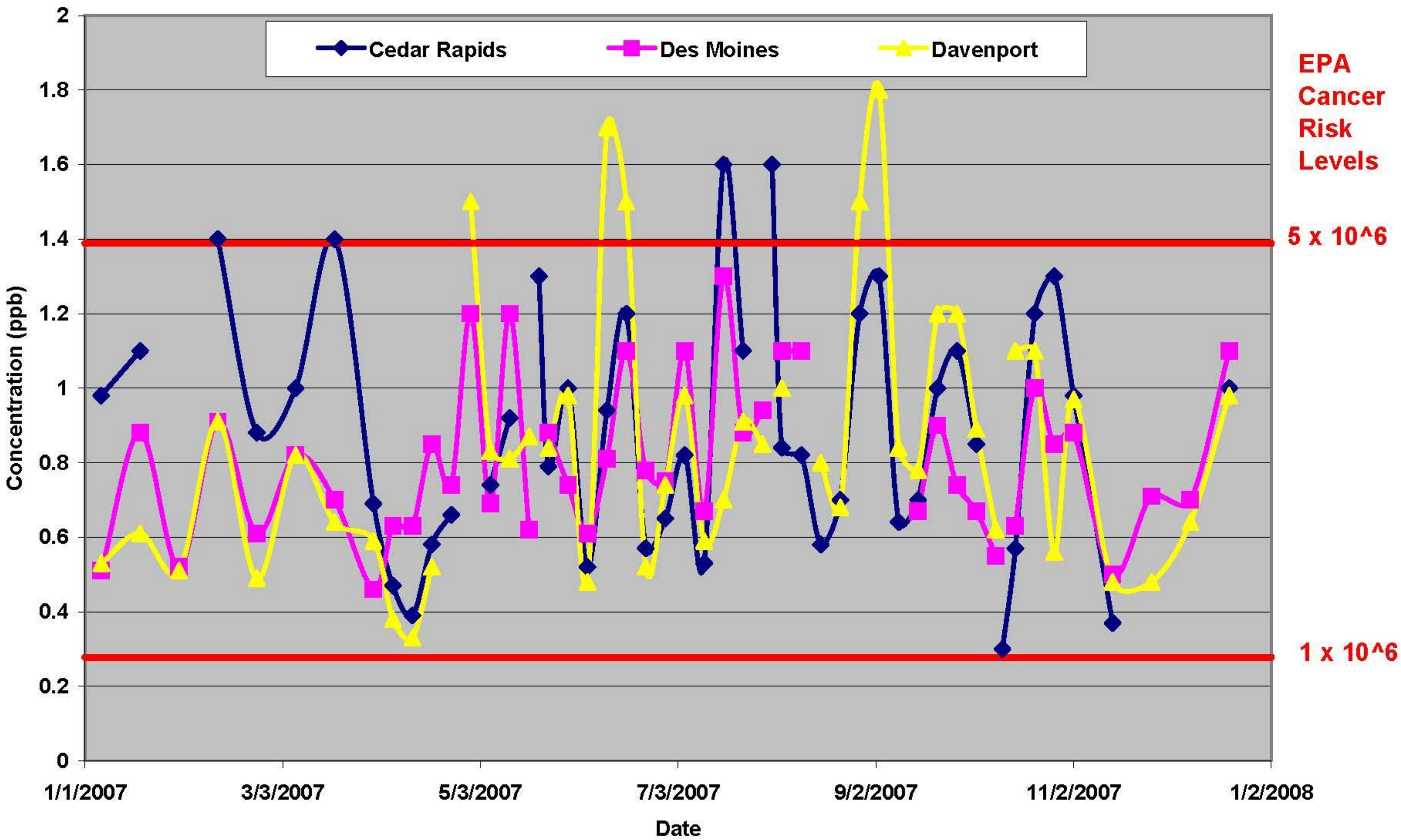
Air Toxics with Cancer Risks Over The EPA Benchmark, 2007



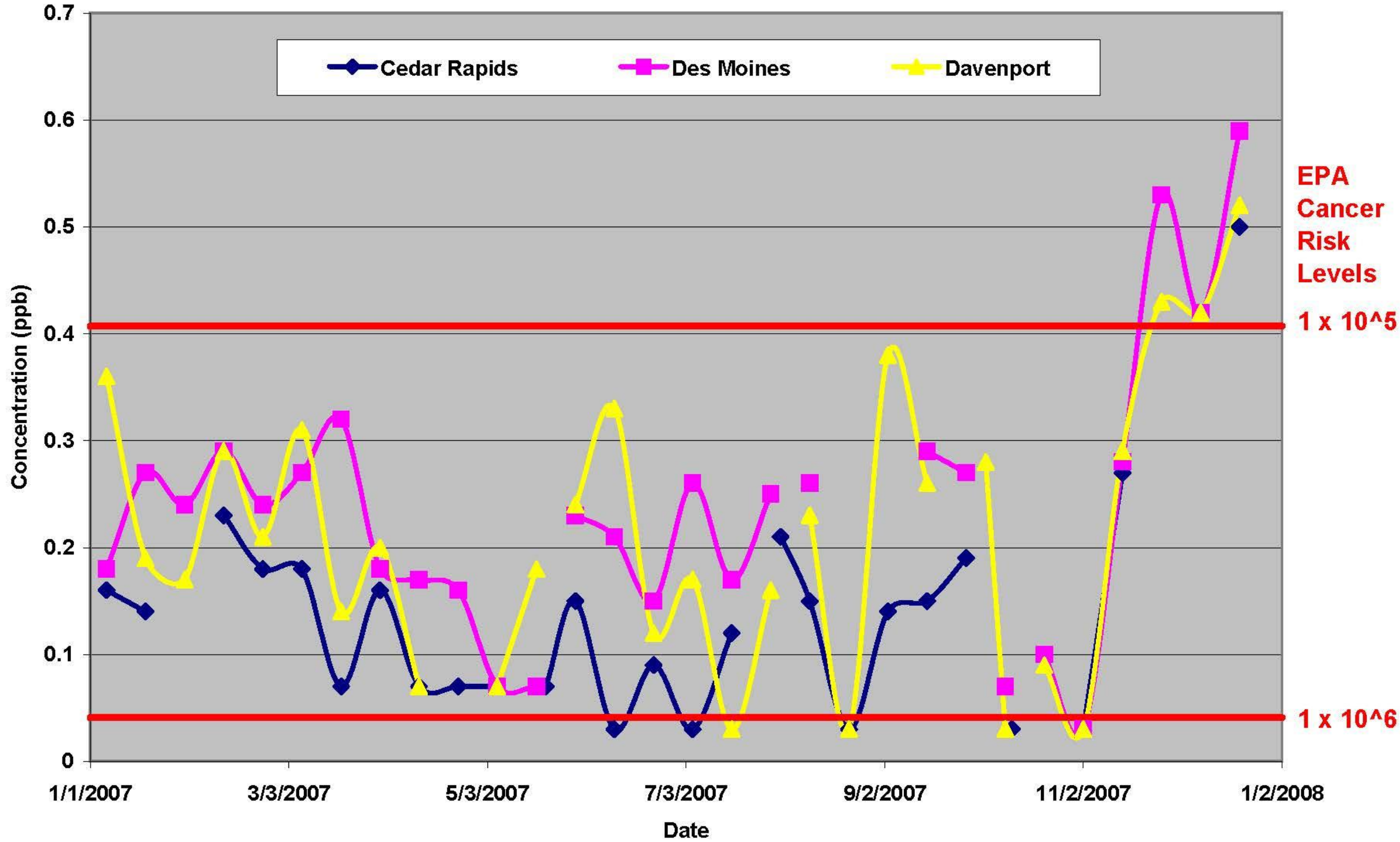
Formaldehyde Cancer Risk 2007



Acetaldehyde Cancer Risk 2007



Benzene Cancer Risk 2007



Raw Data - Formaldehyde
(Concentration in ppb)

Date	Cedar Rapids Army Reserve	Des Moines Public Health Building	Davenport Jefferson School
1/6/2007	1.1	1.0	0.9
1/18/2007	1.6	1.5	1.7
1/30/2007		0.9	1.1
2/11/2007	2.2	2.2	2.1
2/23/2007	1.6	1.3	1.4
3/7/2007	1.8	1.5	1.6
3/19/2007	2.0	1.9	2.1
3/31/2007	1.2	1.0	1.3
4/6/2007	1.7	1.2	1.1
4/12/2007	1.5	1.7	1.1
4/18/2007	2.2	2.8	1.6
4/24/2007	1.8	1.9	
4/30/2007		3.7	3.4
5/6/2007	2.4	2.0	2.5
5/12/2007	3.0	3.9	2.4
5/18/2007		2.8	2.5
5/21/2007	3.5		
5/24/2007	3.0	1.9	3.3

Date	Cedar Rapids Army Reserve	Des Moines Public Health Building	Davenport Jefferson School
5/30/2007	3.4	2.8	3.7
6/5/2007	1.8	2.3	1.6
6/11/2007	3.4	3.1	4.0
6/17/2007	4.7	4.9	4.8
6/23/2007	2.2	2.4	1.6
6/29/2007	2.3	2.9	2.0
7/5/2007	3.2	4.0	3.0
7/11/2007	2.2	2.3	2.0
7/17/2007	3.0	5.0	1.9
7/23/2007	2.8	4.0	2.5
7/29/2007		3.0	2.6
8/1/2007	3.3		
8/4/2007	3.2	4.4	3.3
8/10/2007	3.5	4.0	
8/16/2007	2.2		2.2
8/22/2007	1.7		2.4
8/28/2007	3.7		4.8
9/3/2007	3.4		4.3
9/9/2007	1.8		3.0
9/15/2007	1.1	1.3	1.8
9/21/2007	2.8	3.1	3.8
9/27/2007	1.8	2.1	2.2
10/3/2007	1.5	1.8	1.8
10/9/2007		1.8	1.5
10/11/2007	0.7		
10/15/2007	1.6	1.6	2.4
10/21/2007	2.4	2.9	3.0
10/27/2007	1.5	2.0	1.4
11/2/2007	1.8	2.0	2.1
11/14/2007	1.0	1.0	1.0
11/26/2007		1.3	0.9
12/8/2007		1.3	1.3
12/20/2007	1.5	1.7	1.2

Raw Data - Acetaldehyde
(Concentration in ppb)

Date	Cedar Rapids Army Reserve	Des Moines Public Health Building	Davenport Jefferson School
1/6/2007	0.98	0.51	0.53
1/18/2007	1.10	0.88	0.61
1/30/2007		0.52	0.51
2/11/2007	1.40	0.91	0.91
2/23/2007	0.88	0.61	0.49
3/7/2007	1.00	0.82	0.82
3/19/2007	1.40	0.70	0.64
3/31/2007	0.69	0.46	0.59
4/6/2007	0.47	0.63	0.38
4/12/2007	0.39	0.63	0.33
4/18/2007	0.58	0.85	0.52
4/24/2007	0.66	0.74	
4/30/2007		1.20	1.50
5/6/2007	0.74	0.69	0.83
5/12/2007	0.92	1.20	0.81
5/18/2007		0.62	0.87
5/21/2007	1.30		
5/24/2007	0.79	0.88	0.84
5/30/2007	1.00	0.74	0.98
6/5/2007	0.52	0.61	0.48
6/11/2007	0.94	0.81	1.70
6/17/2007	1.20	1.10	1.50
6/23/2007	0.57	0.78	0.52
6/29/2007	0.65	0.75	0.74
7/5/2007	0.82	1.10	0.98
7/11/2007	0.53	0.67	0.59
7/17/2007	1.60	1.30	0.70
7/23/2007	1.10	0.88	0.91
7/29/2007		0.94	0.85
8/1/2007	1.60		
8/4/2007	0.84	1.10	1.00
8/10/2007	0.82	1.10	
8/16/2007	0.58		0.80
8/22/2007	0.70		0.68
8/28/2007	1.20		1.50
9/3/2007	1.30		1.80
9/9/2007	0.64		0.84
9/15/2007	0.70	0.67	0.78
9/21/2007	1.00	0.90	1.20
9/27/2007	1.10	0.74	1.20
10/3/2007	0.85	0.67	0.89

Date	Cedar Rapids Army Reserve	Des Moines Public Health Building	Davenport Jefferson School
10/9/2007		0.55	0.62
10/11/2007	0.30		
10/15/2007	0.57	0.63	1.10
10/21/2007	1.20	1.00	1.10
10/27/2007	1.30	0.85	0.56
11/2/2007	0.98	0.88	0.97
11/14/2007	0.37	0.50	0.48
11/26/2007		0.71	0.48
12/8/2007		0.70	0.64
12/20/2007	1.00	1.10	0.98

Raw Data - Benzene
(Concentration in ppb)

Date	Cedar Rapids Army Reserve	Des Moines Public Health Building	Davenport Jefferson School
1/6/2007	0.16	0.18	0.36
1/18/2007	0.14	0.27	0.19
1/30/2007		0.24	0.17
2/11/2007	0.23	0.29	0.29
2/23/2007	0.18	0.24	0.21
3/7/2007	0.18	0.27	0.31
3/19/2007	0.11*	0.32	0.14
3/31/2007	0.16	0.18	0.20
4/12/2007	0*	0.17	0.11*
4/24/2007	0.11*	0.16	
5/6/2007	0.09*	0.12*	0.11*
5/18/2007		0.13*	0.18
5/21/2007	0.13*		
5/30/2007	0.15	0.23	0.24
6/11/2007	0*	0.21	0.33
6/23/2007	0.09	0.15	0.12
7/5/2007	0*	0.26	0.17
7/17/2007	0.12	0.17	0*
7/29/2007		0.25	0.16
8/1/2007	0.21		
8/10/2007	0.15	0.26	0.23
8/22/2007	0*		0*
9/3/2007	0.14		0.38
9/15/2007	0.15	0.29	0.26
9/27/2007	0.19	0.27	
10/3/2007			0.28

Date	Cedar Rapids Army Reserve	Des Moines Public Health Building	Davenport Jefferson School
10/9/2007		0.07	0.01*
10/11/2007	0*		
10/21/2007		0.10	0.09
11/2/2007	0*	0*	0*
11/14/2007	0.27	0.28	0.29
11/26/2007		0.53	0.43
12/8/2007		0.42	0.42
12/20/2007	0.50	0.59	0.52

(*)asterisks indicate that the sample value reported is less than the minimum detectable limit

Appendix A. Precision Calculations

Let c_i^1 and c_i^2 represent two concentrations from a particular monitoring location taken on the same day. If both are greater than the MDL, then they may be used to estimate the precision of the data at the sampling location as follows:

First compute the average:

$$\overline{c_i} = \frac{c_i^1 + c_i^2}{2}$$

And the mean difference:

$$d_i = \frac{c_i^1 - c_i^2}{c_i}$$

Define the coefficient of variation for the pair of samples as:

$$CV_i = \frac{d_i}{\sqrt{2}}$$

Compute the root mean square of the individual coefficients of variation to determine the coefficient of variation of the data at the site for the entire year:

$$CV = \sqrt{\frac{\sum_{i=1}^{n} CV_i^2}{n}}$$

Finally, compute confidence limits in the usual way:

$$Lower\ Confidence\ Limit = CV = \sqrt{\frac{n}{X_{(.05,n)}^{-1}}}$$

$$Upper\ Confidence\ Limit = CV = \sqrt{\frac{n}{X_{(.95,n)}^{-1}}}$$

Where X^{-1} represents the inverse of the chi-squared distribution.