



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

MAR 25 2009

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

MEMORANDUM

SUBJECT: Air Quality Statistics for Cities Referenced in Key U.S. and Canadian Epidemiological Studies of Hospital Admission and Emergency Department Visits for All Respiratory Causes and Asthma

FROM: Rhonda Thompson, Air Quality Analysis Group
Michael Stewart, Ambient Standards Group

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TO: SO₂ NAAQS Review Docket

To inform the review of the primary National Ambient Air Quality Standards (NAAQS) for Sulfur Oxides (SO_x), we have characterized 24-hour average, and 1-hour daily maximum Sulfur Dioxide (SO₂) levels in locations and time periods corresponding to key U.S. and Canadian ED visit and hospitalization studies for all respiratory causes and asthma. In brief, authors of relevant U.S. and Canadian studies were contacted and air quality statistics from the study monitor that recorded the highest SO₂ levels were requested. In some cases, U.S. authors provided the AQS monitor IDs used in their studies and the statistics from the highest reporting monitor were calculated by EPA (see below). In cases where U.S. authors did not provide the requested data, EPA identified the maximum reporting monitor from all monitors located in the study area and calculated the 98th and 99th percentile statistics (see below). Key epidemiological studies were identified from Table 5-5 of the *Integrated Science Assessment for Sulfur Oxides-Health Criteria*, and the results of this analysis are presented in the *Risk and Exposure Assessment to Support the Review of the SO₂ Primary National Ambient Air Quality Standards: Second Draft* (see Figures 5-1 to 5-5 and Chapter 10). In addition, for each individual study, a description of the methods used to obtain these statistics is included below.

The analysis conducted by Peel et al., (2005) covered the time period 1/1/1993-8/31/2000 in Atlanta, Georgia. For this study, the authors submitted mean, 98th percentile, and 99th percentile 1-hour daily maximum SO₂ concentrations. We calculated the mean, 98th, and 99th percentiles of the daily average (24-hour average) from the monitor reporting the highest daily average for the entire period. No data were excluded because of completeness requirements; all

data for each site were used. The information provided by the authors and the information calculated by EPA are provided in Attachment 1.

The analysis conducted by Tolbert et al., (2007) covered the time period 1/1/1993-12/31/2004 in Atlanta, Georgia. For this study, the authors submitted mean, 98th percentile, and 99th percentile 1-hour daily maximum SO₂ concentrations. We calculated the mean, 98th, and 99th percentiles of the daily average (24-hour average) from the monitor reporting the highest daily average for the entire period. No data were excluded because of completeness requirements; all data for each site were used. The information provided by the authors and the information calculated by EPA are provided in Attachment 1.

The analysis conducted by Lin et al., (2004) covered the time period 1991-1993 in Bronx, New York. The author supplied station numbers but not AQS monitor ID numbers. The New York Department of Conservation provided the corresponding AQS monitor ID numbers (360050073 and 360050080). We calculated the mean, 98th, and 99th percentiles of the daily average (24-hour average) and the 1-hour daily maximum for the entire study period. No data were excluded because of completeness requirements; all data for each site were used. Data from these sites are presented in Attachment 2.

The analysis conducted by Ito et al., (2007) covered the time period 1/1/1999-12/31/2002 in New York, New York. The authors provided the monitor recording the highest 24-hour average during the study period (id 360050030). We calculated the mean, 99th, and 98th percentiles of the daily average (24-hour average) and the 1-hour daily maximum for all monitors in the New York CMSA and determined that the monitor identified by the author also yielded the highest 1-hour daily maximum concentration during the study period. The statistics for the monitor are in Attachment 3.

The analysis conducted by Schwartz et al., (1995) covered the time period 1/1/1988-12/31/90 in New Haven, Connecticut, and Tacoma, Washington. EPA did not receive any author supplied data for this study; therefore, we calculated the mean, 98th, and 99th percentiles of the daily average (24-hour average) and the 1-hour daily maximum for both study cities for the entire study period. No data were excluded because of completeness requirements; all data for each site were used. Data from the site recording the highest SO₂ concentrations are presented in Attachment 4.

The analysis conducted by Schwartz et al., (1996) covered the time period 1/1/1988-12/31/90 in Cleveland, Ohio. EPA did not receive any author supplied data for this study; therefore, we calculated the mean, 98th, and 99th percentiles of the daily average (24-hour average) and the 1-hour daily maximum for the entire study period. No data were excluded because of completeness requirements; all data for each site were used. Data from the site recording the highest SO₂ concentrations are presented in Attachment 5.

The analysis conducted by Wilson et al., (2005) had two study periods and cities. The authors provided a daily summary file from January 1998 to December 2000 for Portland and a

daily summary file from January 1996 to December 2000 for Manchester. Each spreadsheet had a column labeled SO2.Max for the 1-hour daily maximum and a column labeled SO2.IDAY for the daily average (24-hour average) and a row for each day. From this spreadsheet, we calculated the 99th and 98th percentiles for both the 1-hour daily maximum and the daily average in the file PortManch_ER_Nohealth.xls. EPA calculations are presented in Attachment 6. The author provided daily summary file is available at: <http://www.epa.gov/ttn/analysis/so2.htm>.

The analysis conducted by the New York Department of Health (2006) covered the time period from January 1999 to 2000 in Manhattan. The authors provided all requested statistics in Attachment 7.

The analysis conducted by Jaffe et al., (2003) covered the time period from June to August from 1991-1996 in Cincinnati, Cleveland, and Columbus, Ohio. We extracted from AQS SO₂ data from all monitors in all three MSA's (because specific sites utilized in their analysis were not listed in the paper) for the study period. We calculated the mean, 98th, and 99th percentiles of the daily average (24-hour average) and the 1-hour daily maximum for the entire period. No data were excluded because of completeness requirements; all data for each site were used. In Attachment 8, we report the mean, 98th, and 99th percentile SO₂ concentrations from the monitor reporting the highest SO₂ concentrations. The highest monitor was based on the 98th percentile of the statistics for the table.

The analysis conducted by Shepherd et al., (2003) covered the time period 1987-1994 in Seattle, Washington. The authors provided daily average (24-hour average) values. Thus, from AQS we extracted SO₂ 1-hour data in King County, Washington, for the study period and calculated the mean, 98th, and 99th percentiles of the 1-hour daily maximum for the entire period. No data were excluded because of completeness requirements; all data for each site were used. Data from the site recording the highest SO₂ concentrations are presented in Attachment 9.

For the Canadian studies: Yang et al., (2003, Vancouver); Burnett et al., (1997, Toronto); and Lin et al., (2003, Toronto), EPA calculated the appropriate statistics from data files provided by Dr. Richard Burnett. Each file contained columns for the daily mean (labeled so2mean) and daily max (labeled so2max) for each day from 1/1/1981 through 12/31/2000 for 12 Canadian cities. From this spreadsheet, we calculated the mean, 99th percentile, and 98th percentile of the 1-hour daily maximum values and the daily average (24-hour average) values for each study period. Those statistics are in tables in Attachment 10. This data set was used for all key single city studies (see ISA, Table 5-5) on which Dr. Burnett was an author. It is important to note that concentrations from Canadian studies may not be directly comparable to U.S. studies because these values likely represent the average SO₂ concentration across multiple monitors in a city rather than the SO₂ concentration from the monitor that recorded the highest SO₂ levels in a particular city. The author provided daily summary files are available at: <http://www.epa.gov/ttn/analysis/so2.htm>.

Attachments

References

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Yang Q.; Chen, Y.; Shi Y.; Burnett R. T.; McGrail K.M.; Krewski D. (2003) Association Between Ozone and Respiratory Admissions Among Children and the Elderly in Vancouver, Canada. *Inhalation Toxicology*; 15:1297-1308.

Attachment 1 Peel and Tolbert Tables
 1993-2004 all units ppm unless otherwise indicated

Table 1 daily average (24 hour average) - entire period 1/1/93-12/31/2004

State_Code	County_Code	Site_ID	mean	nobs	p99	pp98
13	121	48	0.0042	4268	0.0183	0.0153

Table 4 Author supplied Descriptive statistics for 1-hour max NO2 from Georgia Tech monitor
 Study Period 1/1/93-8/31/2000

N	Mean	98 th percentil e	99 th percentil e
2775*	16.5 ppb	70.0 ppb	81.0 ppb

* out of 2800 days in study period

Study Period 1/1/93-12/31/2004

N	Mean	98 th percentil e	99 th percentil e
4358*	14.9 ppb	62.0 ppb	76.0 ppb

* out of 4383 days in study period

Attachement 2 Lin Tables

1/1/91 -12/31/1993 NY all units ppm unless otherwise indicated

Table 1 - daily average (24-hour average)

Mon id	mean	99th	98th	n
360050073	0.0143	0.0448	0.0387	1096
360050080	0.0185	0.053	0.0476	1078

Table 2 - 1-hour daily maximum

Mon id	mean	99th	98th	n
360050073	0.0325	0.119	0.093	1096
360050080	0.0347	0.112	0.093	1078

Attachment 3 Ito Tables

1/1/99 -12/31/2002 NY all units ppm unless otherwise indicated

Table 1 - daily average (24-hour average)

Mon id	mean	99th	98th	n
360050080	0.0126	0.0394	0.036	488

Table 2 - 1-hour daily maximum

Mon id	mean	99th	98th	n
360050080	0.0251	0.082	0.071	488

Attachment 4 Schwartz Tables

1/1/88 to 12/31/90 all units ppm unless otherwise indicated

Table 1 highest site - daily average (24-hour average)		mean	99th	98th	n
New Haven CT	090091123	0.0154	0.0639	0.0524	1091
Tacoma WA	530530021	0.0074	0.0308	0.0232	969

Table 2 highest site - 1-hour daily maximum		mean	99th	98th	n
New Haven CT	090091123	0.0338	0.15	0.126	1091
Tacoma WA	530530021	0.0237	0.1	0.089	969

Attachment 5 Schwartz Tables

1/1/88 to 12/31/90 all units ppm unless otherwise indicated

Table 1 - daily average (24-hour average)

	Mon id	mean	99th	98th	n
Cleveland	390350038	0.0161	0.058	0.055	1088

Table 2 - 1-hour daily maximum

	Mon id	mean	99th	98th	n
Cleveland	390350038	0.0505	0.17	0.15	1088

Attachment 6 Wilson Tables

Table 1 Portland 1998-2000

1998-2000	99th	98th	mean	n
SO2.Max	47.310	36.240	11.085	970
SO2.1Day	16.544	14.000	4.657	970

Table 2 Manchester 1996-2000

SO2.Max	69.000	59.040	16.530	1650
SO2.1Day	24.047	21.792	6.634	1650

Summary statistics for sulfur dioxide and nitrogen dioxide from NYSDOH study of ambient air pollutants and asthma ED visits in Manhattan and Bronx, NYC (NYSDOH 2006. A study of ambient air contaminants and asthma in New York City. ATSDR Final Report. PB2006-113523).

site*	N	Concentration (ppm)		
		mean	98 th percentile	99 th percentile
NO2 24-hour averages				
Manhattan	625	0.036	0.057	0.060
Bronx (all days)	425	0.031	0.057	0.060
site A	102	0.030	0.054	0.057
site B	323	0.032	0.057	0.062
NO2 1-hour averages				
Manhattan	14980	0.036	0.065	0.070
Bronx (all days)	10073	0.031	0.065	0.071
site A	2422	0.030	0.065	0.072
site B	7651	0.032	0.065	0.070
NO2 maximum daily 1-hour averages				
Manhattan	625	0.050	0.086	0.093
Bronx (all days)	425	0.049	0.088	0.098
site A	102	0.049	0.083	0.094
site B	323	0.049	0.088	0.098
SO2 24-hour averages				
Manhattan	648	0.012	0.033	0.036
Bronx (all days)	608	0.011	0.031	0.036
site A	194	0.010	0.032	0.035
site B	414	0.011	0.031	0.037
SO2 1-hour averages				
Manhattan	15426	0.012	0.039	0.045
Bronx (all days)	14317	0.011	0.039	0.047
site A	4565	0.010	0.037	0.046
site B	9752	0.011	0.040	0.048
SO2 maximum daily 1-hour averages				
Manhattan	648	0.024	0.062	0.080
Bronx (all days)	608	0.023	0.065	0.078
site A	194	0.022	0.060	0.068
site B	414	0.024	0.068	0.086

*Manhattan = Mabel Dean Bacon HS (site # 7093-05N) operated from January 1, 1999 – November 22, 2000

Bronx site A = IS155 (site # 7094-03) operated from January 1 – July 14, 1999; operation was discontinued due to building construction at the site

Bronx site B = Middle School 52 at 681 Kelly Street Bronx NY, approximately 0.5 miles northeast of site # 7094-03; operated from September 2, 1999 – November 22, 2000; this site was approved by US EPA during the study as an acceptable alternative as an urban regional site to replace the discontinued Bronx monitoring location

Attachment 8 Jaffe Tables
June - August

1991-1996

Cincinnati

Mon id 390611020	mean	99th	98th	n
daily average (24-hour average)	0.0283	0.1146	0.0992	92
1-hour daily maximum	0.1204	0.457	0.401	92

Cleveland

Mon id 390350038	mean	99th	98th	n
daily average (24-hour average)	0.0129	0.0459	0.0412	551
1-hour daily maximum	0.0455	0.211	0.175	551

Columbus

Mon id 390490004	mean	99th	98th	n
daily average (24-hour average)	0.004	0.016	0.013	552
1-hour daily maximum	0.011	0.051	0.042	552

Attachment 9 Shepherd Tables
1/1/87 -12/31/1994

Seattle

Mon id 530330057	mean	99th	98th	n
daily average (24-hour average)	0.008	0.022	0.019	2799
1-hour daily maximum	0.021	0.084	0.070	2799

Attachment 10 Burnett Toronto

Entire period:
 June16toSept24, 1992
 May1toSept22, 1993
 May1toSept22, 1994

Entire Period	mean	99th	98th	n
daily average (24-hour average)	3.329	9.525	8.800	391
1-hour daily maximum	7.719	20.830	19.336	391

Lin Toronto

Entire period:
 1981-1994

Entire Period	mean	99th	98th	n
daily average (24-hour average)	4.892	21.460	17.553	5113
1-hour daily maximum	15.013	58.330	50.000	5113

Yang Vancouver

Entire period:
 1986-1998

Entire Period	mean	99th	98th	n
daily average (24-hour average)	4.839	14.000	12.500	4748
1-hour daily maximum	13.319	40.882	35.250	4748