Charleston County, South Carolina, Air Monitoring Study,

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Executive Summary

Indoor air quality was assessed in 64 bars and restaurants in Charleston County, South Carolina, between January 24, 2006 and April 5, 2006 using the TSI SidePak AM510 Personal Aerosol Monitor. Venues were sampled in Charleston, North Charleston, and Mount Pleasant. Nineteen (30 %) venues sampled were smoke-free and 45 venues were not smoke-free. $PM_{2.5}$ levels in these 64 locations were compared, and key findings of the study include:

- The level of $PM_{2.5}$ was 95% lower in the smoke-free venues compared to those venues where smoking was permitted without restrictions. $PM_{2.5}$ is the concentration of particulate matter in the air less than 2.5 microns in diameter. Particles of this size are released in significant amounts from burning cigarettes and are easily inhaled deep into the lungs, with serious health effects.

- Employees in Charleston County, South Carolina, hospitality venues allowing indoor smoking are exposed to levels of particulate matter in excess of levels recommended by the Environmental Protection Agency (EPA) to protect public health. Based on the average $PM_{2.5}$ level observed in all venues in this study where smoking was allowed (260 $\mu g/m^3$), full-time bar and restaurant employees are exposed to four times the annual EPA exposure limit of fine particulate air pollution, solely from occupational exposure.

Introduction

Secondhand smoke (SHS) contains at least 250 chemicals that are known to be toxic or carcinogenic, and is itself a known human carcinogen,[1] responsible for an estimated 3,000 lung cancer deaths annually in *never smokers* in the U.S. as well as over 35,000 deaths annually from coronary heart disease in *never smokers* and respiratory infections, asthma, Sudden Infant Death Syndrome, and other illnesses in children.[2] Although population-based data show declining SHS exposure in the U.S. overall, SHS exposure remains a major public health concern that is entirely preventable.[3,4] Because policies requiring smoke-free environments are the most effective method for reducing SHS exposure in public places,[5] Healthy People 2010 Objective 27-13 encourages all states and the District of Columbia to establish clean indoor air laws, and to enforce smoking restrictions in public places and worksites.[6] Currently, 12 states (California, Connecticut, Delaware, Maine, Massachusetts, Montana, New Jersey, New York, Rhode Island, Utah, Vermont, and Washington), the District of Columbia and Puerto Rico, which represent approximately 31% of the US population, have passed comprehensive clean indoor air regulations that cover virtually all indoor worksites including bars and restaurants.

The purpose of the Charleston County, SC, Air Monitoring Study was to examine indoor air quality in a sample of hospitality venues in and near Charleston, SC, and to assess the relation between indoor air pollution and the presence of on-premise smoking. It was hypothesized that indoor air would be less polluted in those venues where smoking is prohibited and where smoking does not occur, than in those places where smoking is

present. This report provides the results of air monitoring done in Charleston, North Charleston, and Mount Pleasant through April 2006.

Methods

Overview

Between January 24, 2006 and April 5, 2006, indoor air quality was assessed in 64 bars and restaurants in Charleston County, SC. The smoking policies in restaurants and bars in South Carolina are at the discretion of the owner. Nineteen (30%) venues sampled were smoke-free and 45 venues were not smoke-free.

Procedure for Selection of Cities and Venues to be Sampled

The 64 venues were selected to get a broad range of size, location and type of venue. With the help of local contacts, a list of candidate venues believed to be representative of hospitality venues in the Charleston area was created. This list served as the basis for selecting venues for air sampling. Additional locations, which were in close proximity to other locations sampled, were selected throughout the course of the evening in some areas. Testing was done throughout the days of the week from afternoon through midnight and later. Table 1 presents some general descriptive information on the size and occupancy of each venue.

Table 1. Establishments Sampled in Charleston County, SC

Venue Number	Date Sampled	Size (m3)	Average # People	Average # burning cigs	Active smoker density*	Average $PM_{2.5}$ level
1	1/24/2006	442	35	2	0.45	81
2	1/26/2006	422	20	1	0.24	34
3	1/26/2006	201	18	3	1.61	116
4	1/26/2006	317	10	2	0.53	63
5	1/27/2006	510	167	7	1.44	320
6	1/27/2006	623	100	3	0.54	324
7	1/27/2006	850	138	10	1.14	1047
8	1/27/2006	1586	98	5	0.34	601
9	1/28/2006	450	17	0	0.00	9
10	1/28/2006	589	62	6	1.08	307
11	1/28/2006	163	13	2	0.92	123
12	1/28/2006	249	70	0	0.13	280
13	2/2/2006	178	17	0	0.00	30
14	2/2/2006	168	91	3	1.98	337
15	2/3/2006	340	35	5	1.47	376
16	2/3/2006	2549	65	5	0.18	216
17	2/4/2006	228	5	0	0.00	5
18	2/10/2006	1062	28	1	0.12	112
19	2/10/2006	198	7	1	0.50	47
20	2/10/2006	765	35	3	0.39	2491
21	2/10/2006	906	43	3	0.37	437

Table 1 – Continued: Establishments Sampled in Charleston County, SC

Venue Number	Date Sampled	Size (m3)	Average # People	Average # burning cigs	Active smoker density*	Average $PM_{2.5}$ level
22	2/11/2006	181	22	0	0.00	18
23	2/11/2006	885	67	7	0.79	359
24	2/11/2006	227	48	2	1.03	154
25	2/11/2006	1147	72	9	0.78	564
26	2/16/2006	387	17	2	0.39	33
27	2/16/2006	199	15	0	0.17	43
28	2/16/2006	283	33	4	1.24	177
29	2/17/2006	826	11	1	0.16	66
30	2/17/2006	143	27	3	2.33	218
31	2/17/2006	1606	58	2	0.10	136
32	2/17/2006	352	3	0	0.00	9
33	2/17/2006	1529	53	4	0.26	274
34	2/17/2006	382	24	4	1.05	127
35	2/18/2006	510	28	2	0.33	46
36	2/18/2006	223	16	0	0.15	130
37	2/18/2006	258	14	0	0.00	14
38	2/18/2006	113	7	1	0.59	48
39	2/22/2006	612	57	3	0.44	85
40	2/22/2006	161	24	2	1.04	37
41	2/23/2006	2124	19	3	0.12	67
42	2/23/2006	510	35	4	0.85	506
43	2/23/2006	425	75	4	0.94	247
44	2/25/2006	544	13	1	0.12	46
45	2/25/2006	1606	18	1	0.08	70
46	2/25/2006	459	57	6	1.24	179
47	2/25/2006	2973	72	8	0.27	532
48	3/5/2006	729	54	3	0.34	50
49	3/5/2006	734	31	2	0.27	84
50	3/5/2006	143	13	2	1.17	82
51	4/4/2006	382	22	0	0.00	12
52	4/4/2006	181	14	0	0.00	9
53	4/4/2006	761	32	0	0.00	17
54	4/4/2006	481	19	0	0.00	10
55	4/4/2006	268	8	0	0.00	20
56	4/4/2006	628	16	0	0.00	14
57	4/4/2006	283	5	0	0.00	12
58	4/4/2006	550	17	0	0.00	32
59	4/5/2006	1147	17	0	0.00	12
60	4/5/2006	153	11	0	0.00	10
61	4/5/2006	1795	67	0	0.00	30
62	4/5/2006	816	43	0	0.00	7
63	4/5/2006	446	10	0	0.00	9
64	4/5/2006	883	9	0	0.00	19
Average		654	37	2	0	187

Note: * Average number of burning cigarettes per $100m^3$

Measurement Protocol

The average time spent in each venue was 39 minutes (range, 18 to 107 minutes). The number of people inside the venue and the number of burning cigarettes were recorded every 15 minutes during sampling. These observations were averaged over the time inside the venue to determine the average number of people on the premises and the average number of burning cigarettes. The Strait-Line Sonic Laser Tape (Strait-Line, Huntersville, NC) was used to measure room dimensions and hence the volume of each of the venues. If it was impossible to obtain an accurate measurement due to the size of the venue, obstructions, or the number of people, the measurement was estimated by pacing or walking the distance. One large stride for an average size person equals approximately 3 feet, so for 25 large paces, the distance is 75 feet. Ideally, this method is used to check the measurements from the sonic measure, and only relied on exclusively as a last resort. The active smoker density was calculated by dividing the average number of burning cigarettes by the volume of the room in meters.

A TSI SidePak AM510 Personal Aerosol Monitor (TSI, Inc., St. Paul, MN) was used to sample and record the levels of respirable suspended particles (RSP) in the air. The SidePak uses a built-in sampling pump to draw air through the device and the particulate matter in the air scatters the light from a laser to assess the real-time concentration of particles less than 2.5µm in micrograms per cubic meter, or $PM_{2.5}$. The SidePak was calibrated against a light scattering instrument, which had been previously calibrated and used in similar studies. In addition, the SidePak was zero-calibrated prior to each use by attaching a HEPA filter according to the manufacturer's specifications.

TSI SidePak AM510 Personal Aerosol Monitor

$PM_{2.5}$ is the concentration of particulate matter in the air smaller than 2.5 microns in diameter. Particles of this size are released in significant amounts from burning cigarettes, are easily inhaled deep into the lungs, and are associated with pulmonary and cardiovascular disease and mortality.

Secondhand smoke is not the only source of indoor particulate matter, but $PM_{2.5}$ monitoring is highly sensitive to it. While ambient particle concentrations and cooking are additional sources of indoor particle levels, smoking is by far the largest contributor to indoor air pollution[9]. Furthermore, there is a direct link between levels of RSP and polycyclic aromatic hydrocarbons (PAH), known carcinogens in cigarette smoke, with RSP levels being approximately 3 orders of magnitude greater than PAH's[9].

The equipment was set to a one-minute log interval, which averages the previous 60 one-second measurements. Sampling was discreet in order not to disturb the occupants' normal behavior. The monitor was generally located in a central location on a table or bar and not on the floor so the air being sampled was within the occupants' normal breathing zone. For each venue, the first and last minute of logged data were removed because they

are averaged with outdoors and entryway air. The remaining data points were averaged to provide an average $PM_{2.5}$ concentration within the venue. Trained volunteers in Charleston County, SC, completed the sampling, and Roswell Park Cancer Institute staff analyzed the data.

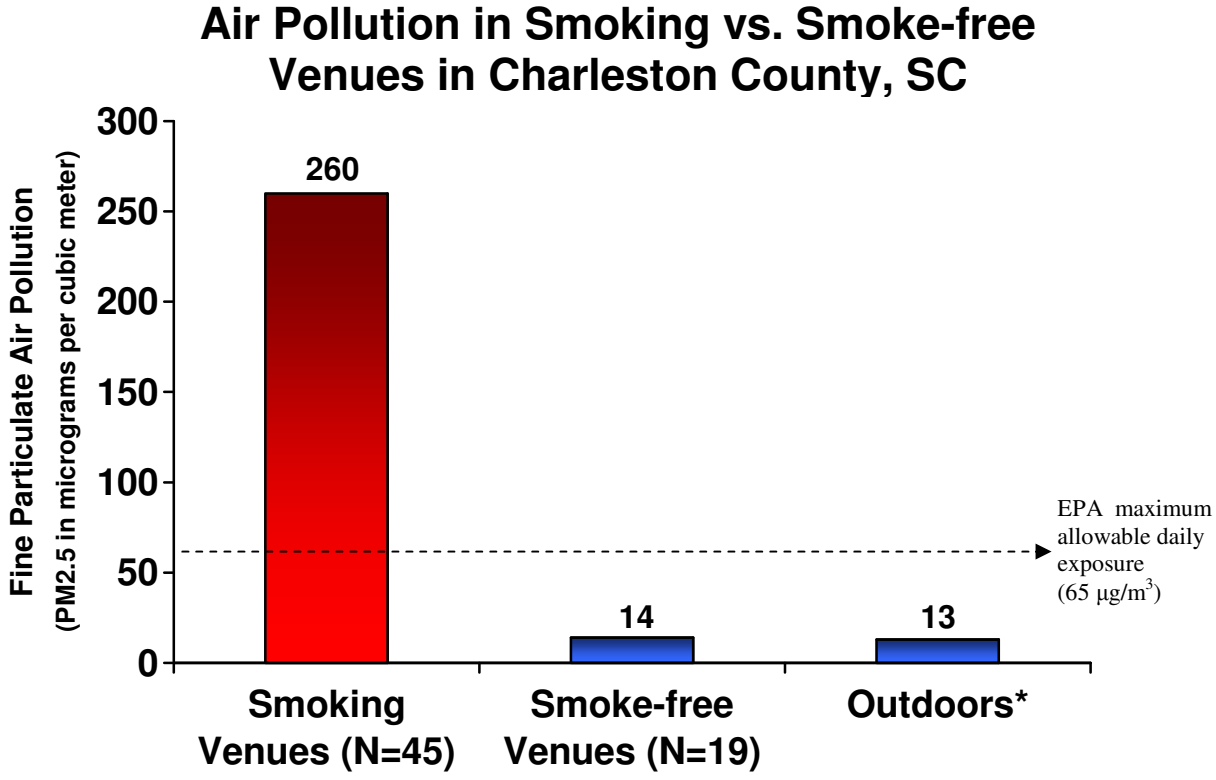
Statistical Analyses

The primary goal was to assess the difference in the average levels of RSP in places that were smoke-free and places that were not. Within each community, the mean RSP are reported across all of the venues sampled and these are compared, with a Mann-Whitney U-test, with the mean levels of all venues in the entire sample that were 'smoke-free' and those that were not. In addition, descriptive statistics including the venue volume, number of patrons, and average smoker density (i.e., number of burning cigarettes) per 100 m^3 are reported for each venue and averaged for all venues.

Results

Across all 64 bars and restaurants sampled in this study, there were 19 smoke-free venues and the average RSP level in these venues was 14 $\mu g/m^3$. Smoking was observed in 45 venues, and the average RSP level in these venues was 260 $\mu g/m^3$ (Figure 1). The level of indoor air pollution was 95% lower in the venues that were smoke-free compared to those where smoking was permitted, and this difference was statistically significant ($p<0.001$) as determined by the Mann-Whitney U-test.

Figure 1



* 2006 Average for Charleston, SC

The average volume of venues sampled was 654 m^3 and was comparable between places where smoking was prohibited and where it was not (539 m^3 vs. 544 m^3, respectively); however, the average smoker density was greater in venues where smoking was unrestricted (1.0 burning cigarettes per 100 m^3 vs. 0.0 burning cigarettes per 100 m^3).

Details on the level of indoor air pollution in each city sampled are presented in Figures 2-13. Results from the real-time $PM_{2.5}$ plots throughout the duration of sampling for each community reveal the following three general trends: 1) much higher levels of indoor air pollution are observed in venues where smoking is permitted; 2) low levels are observed outdoors before and after sampling inside each venue; and 3) peak exposure levels in some venues can reach levels far in excess of the average recorded level.

Figure 2

Charleston County, SC, Air Monitoring Study
January 24th & 26th, 2006

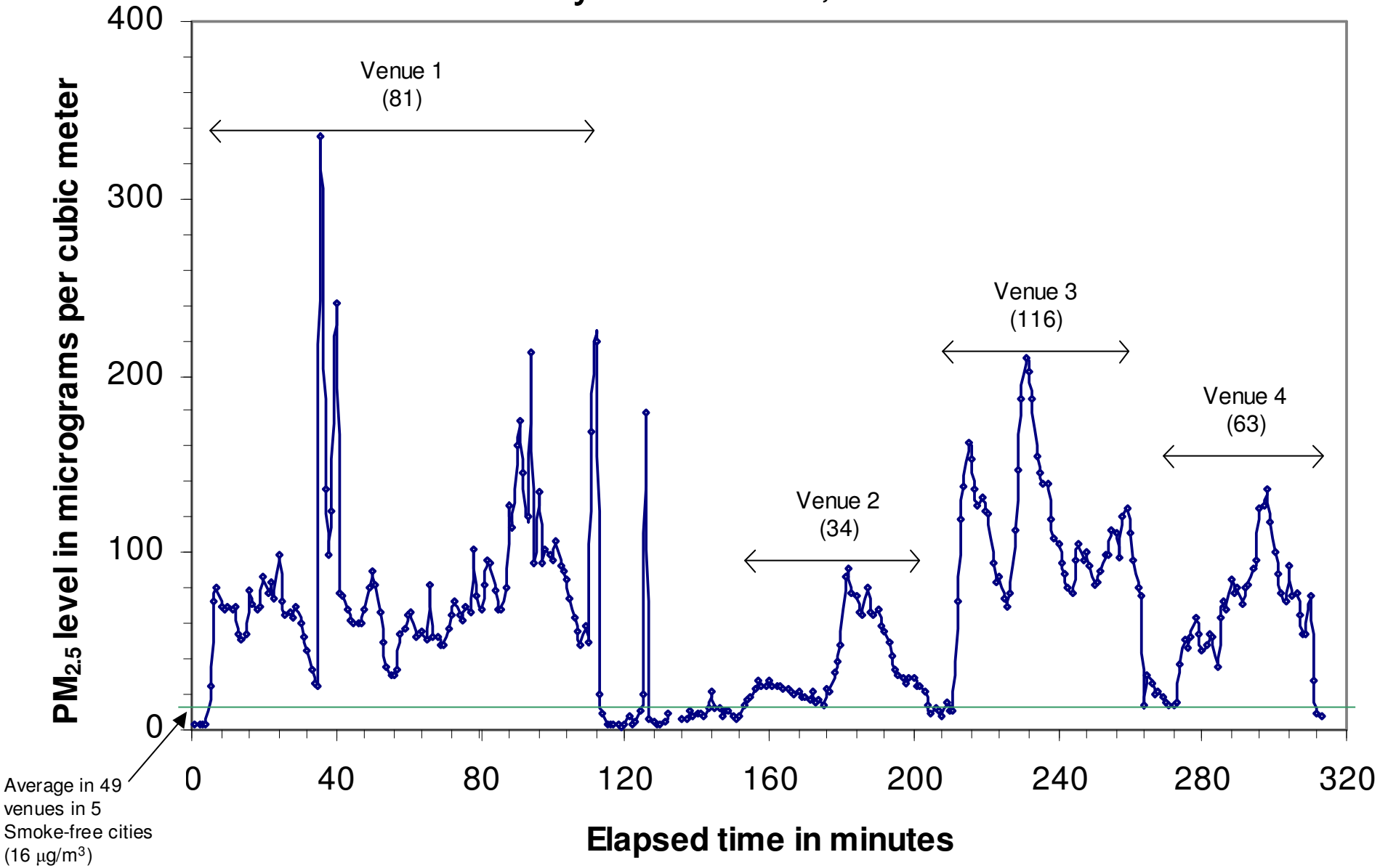


Figure 3

Charleston County, SC, Air Monitoring Study
January 27th & 28th, 2006

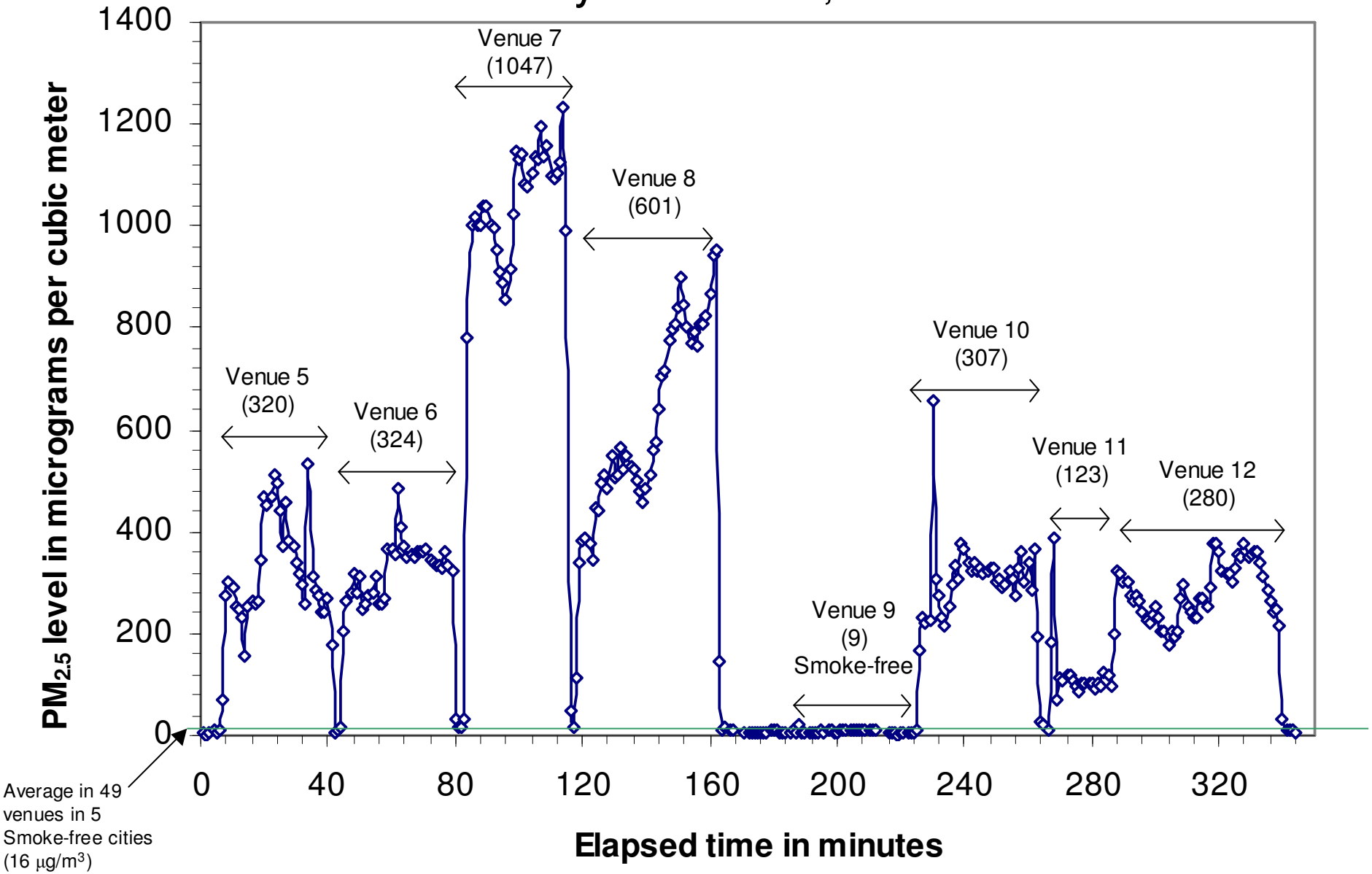


Figure 4

Charleston County, SC, Air Monitoring Study
February 2nd and 3rd, 2006

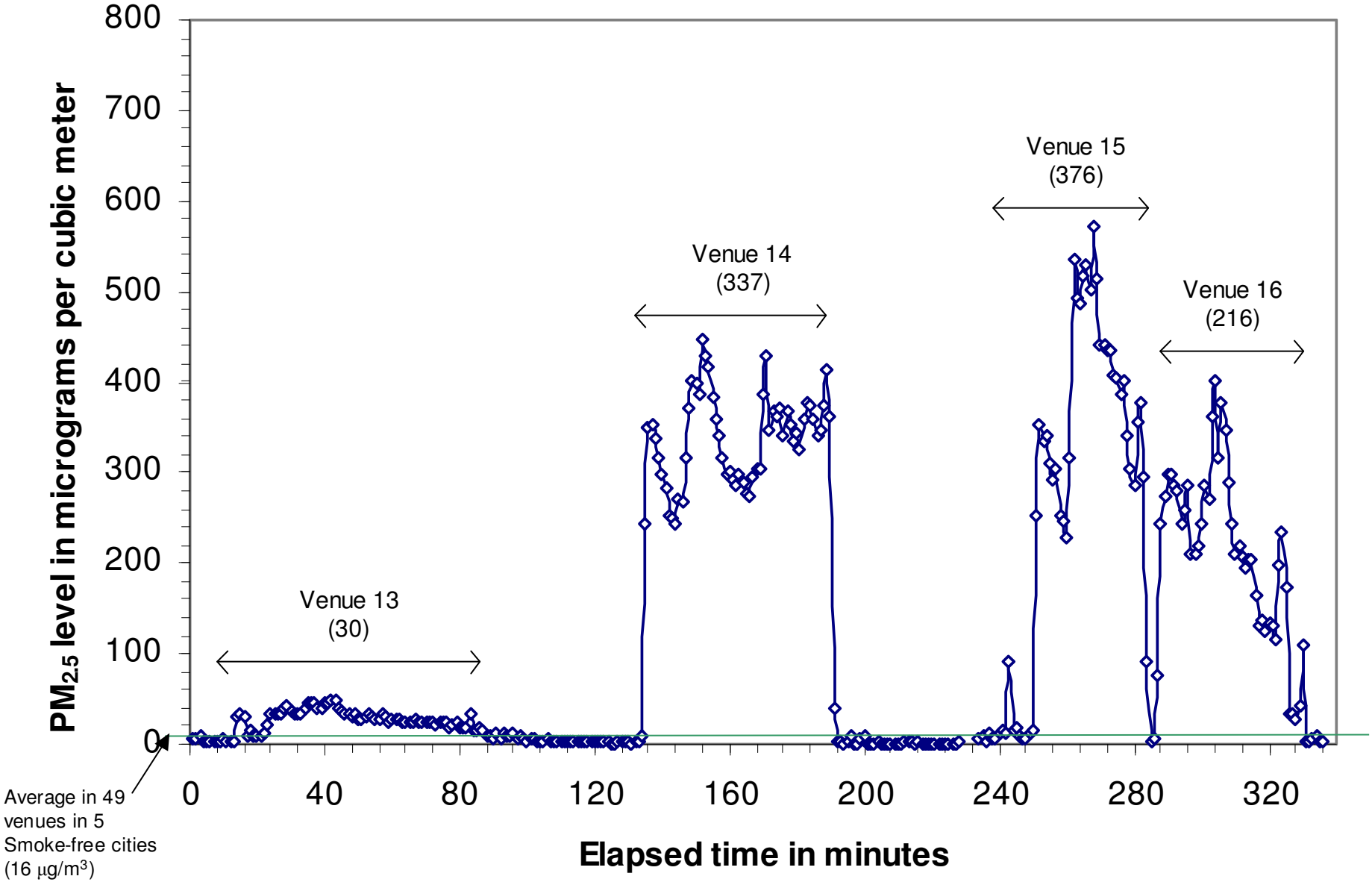


Figure 5

Charleston County, SC, Air Monitoring Study
February 4th & 10th, 2006

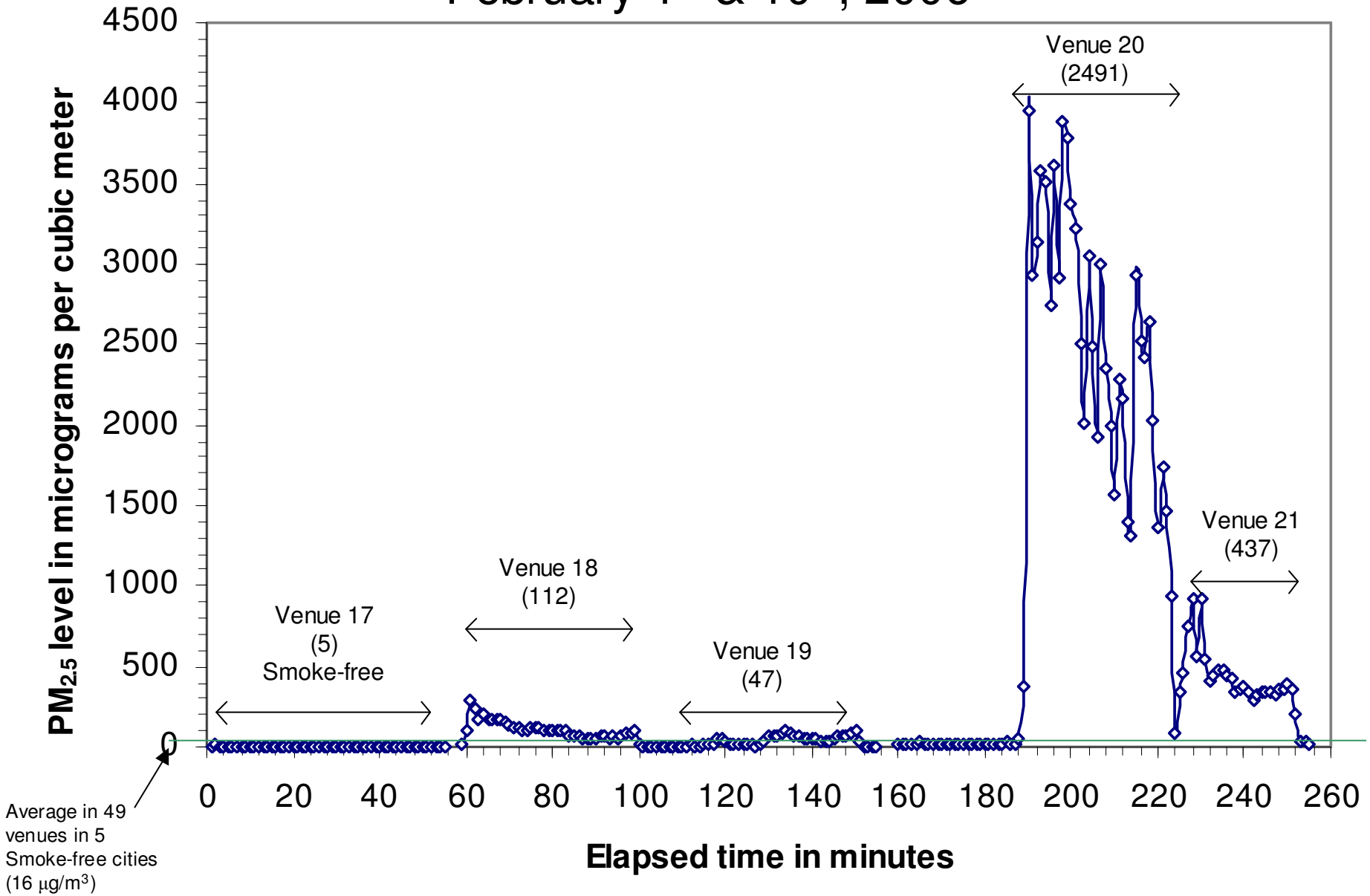


Figure 6

Charleston County, SC, Air Monitoring Study
February 11th, 2006

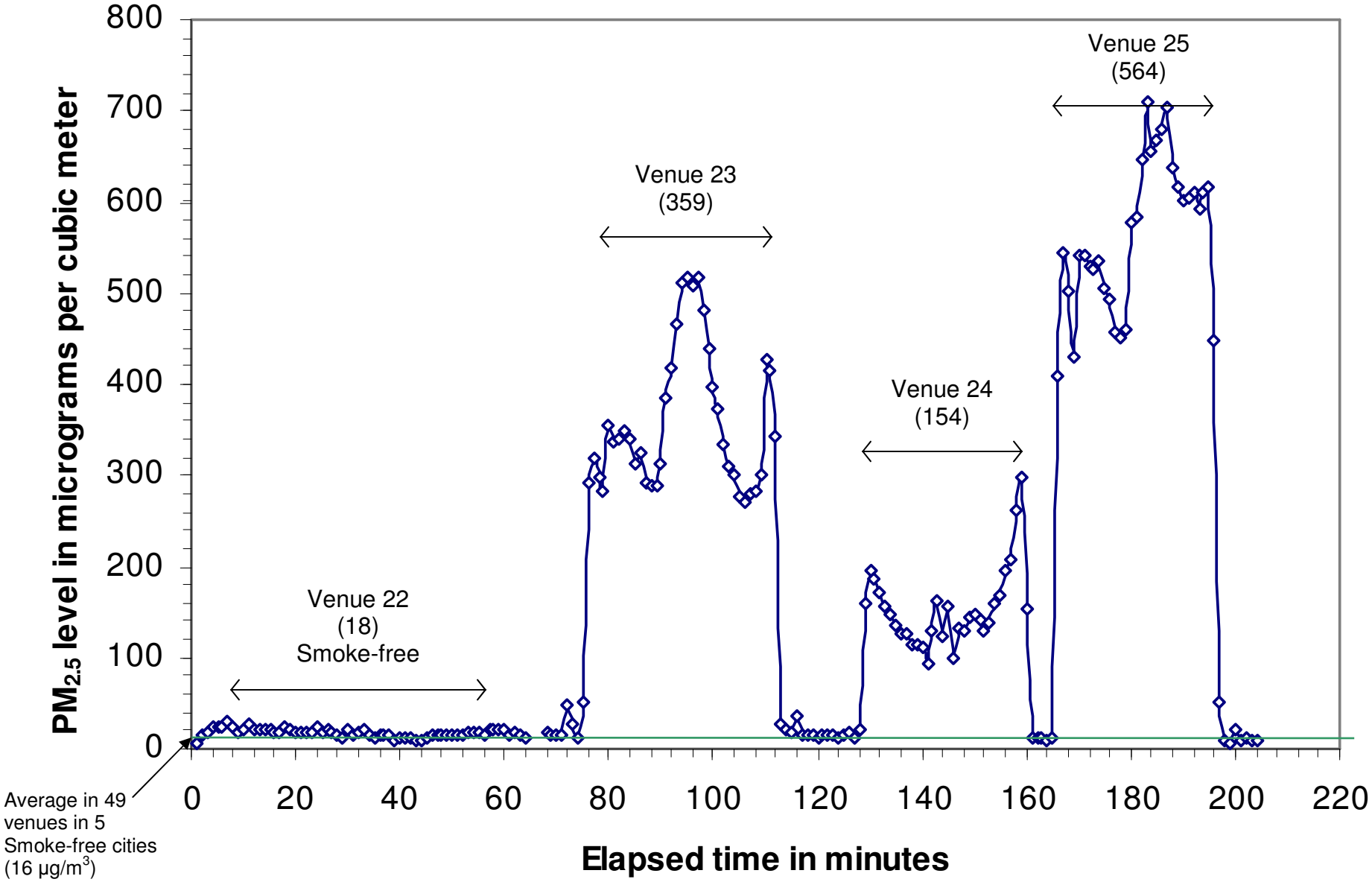


Figure 7

Charleston County, SC, Air Monitoring Study
February 16th & 17th, 2006

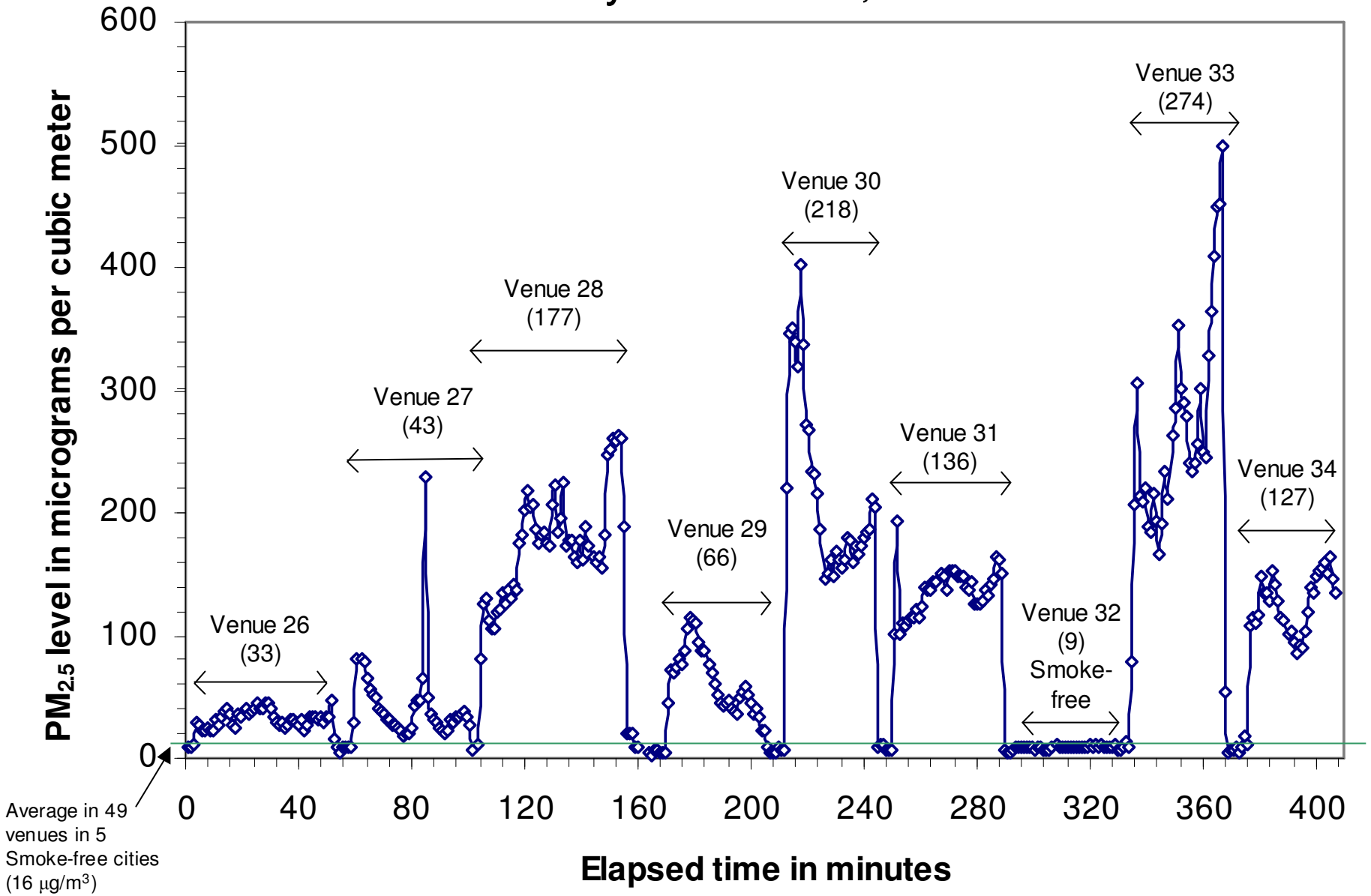


Figure 8

Charleston County, SC, Air Monitoring Study
February 18th & 22th, 2006

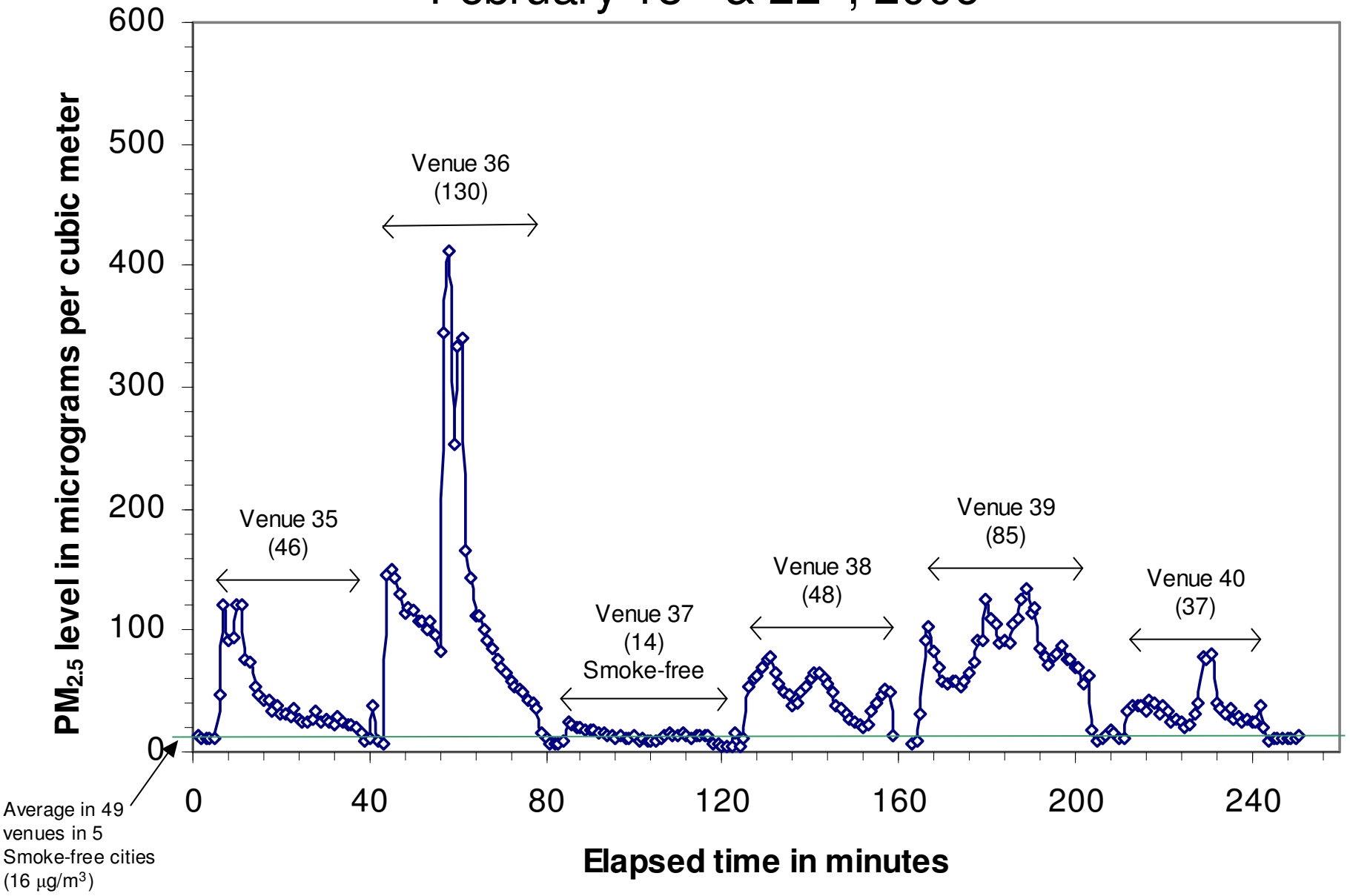


Figure 9

Charleston County, SC, Air Monitoring Study
February 23rd & 25th, 2006

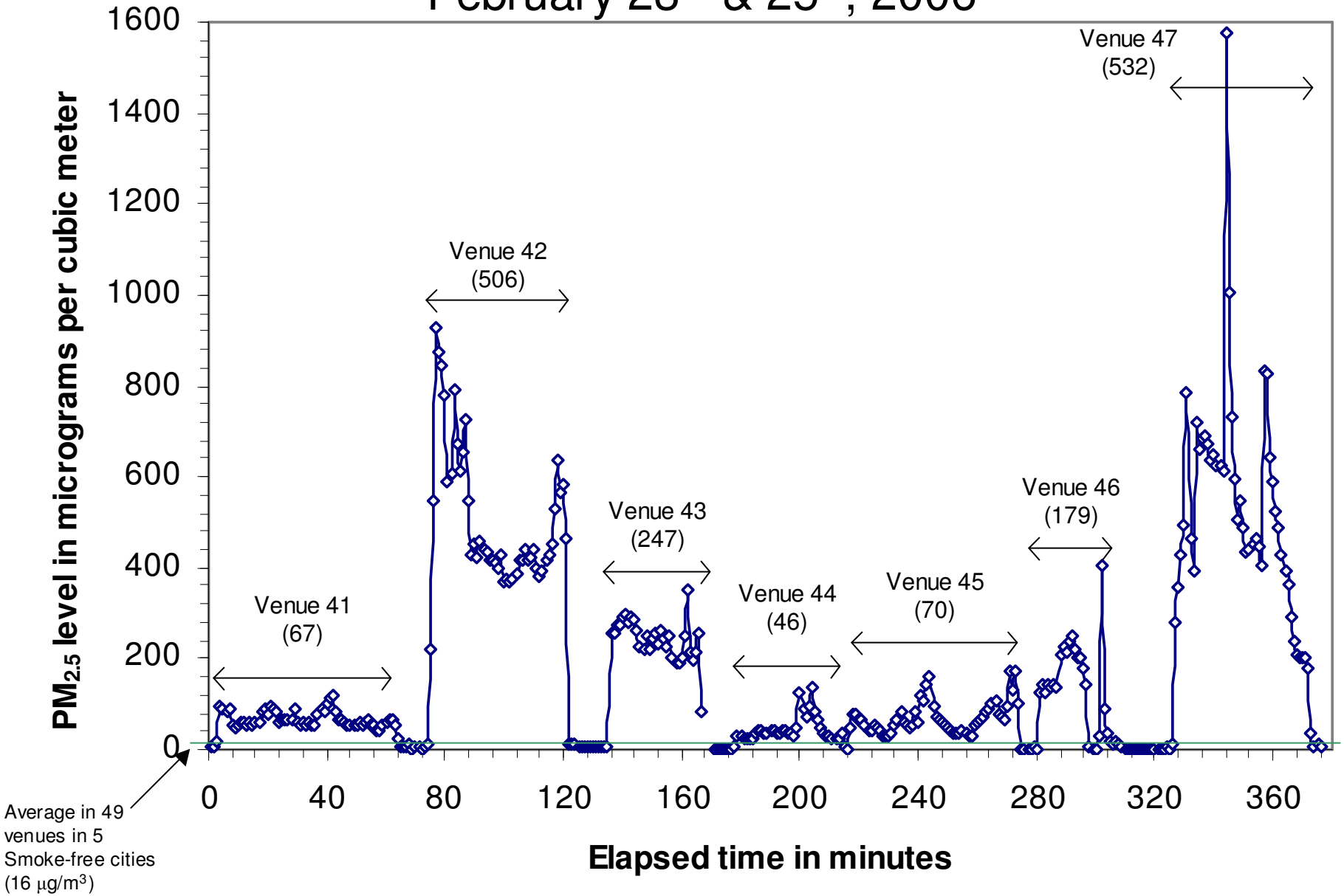


Figure 10

Charleston County, SC, Air Monitoring Study
March 5th, 2006

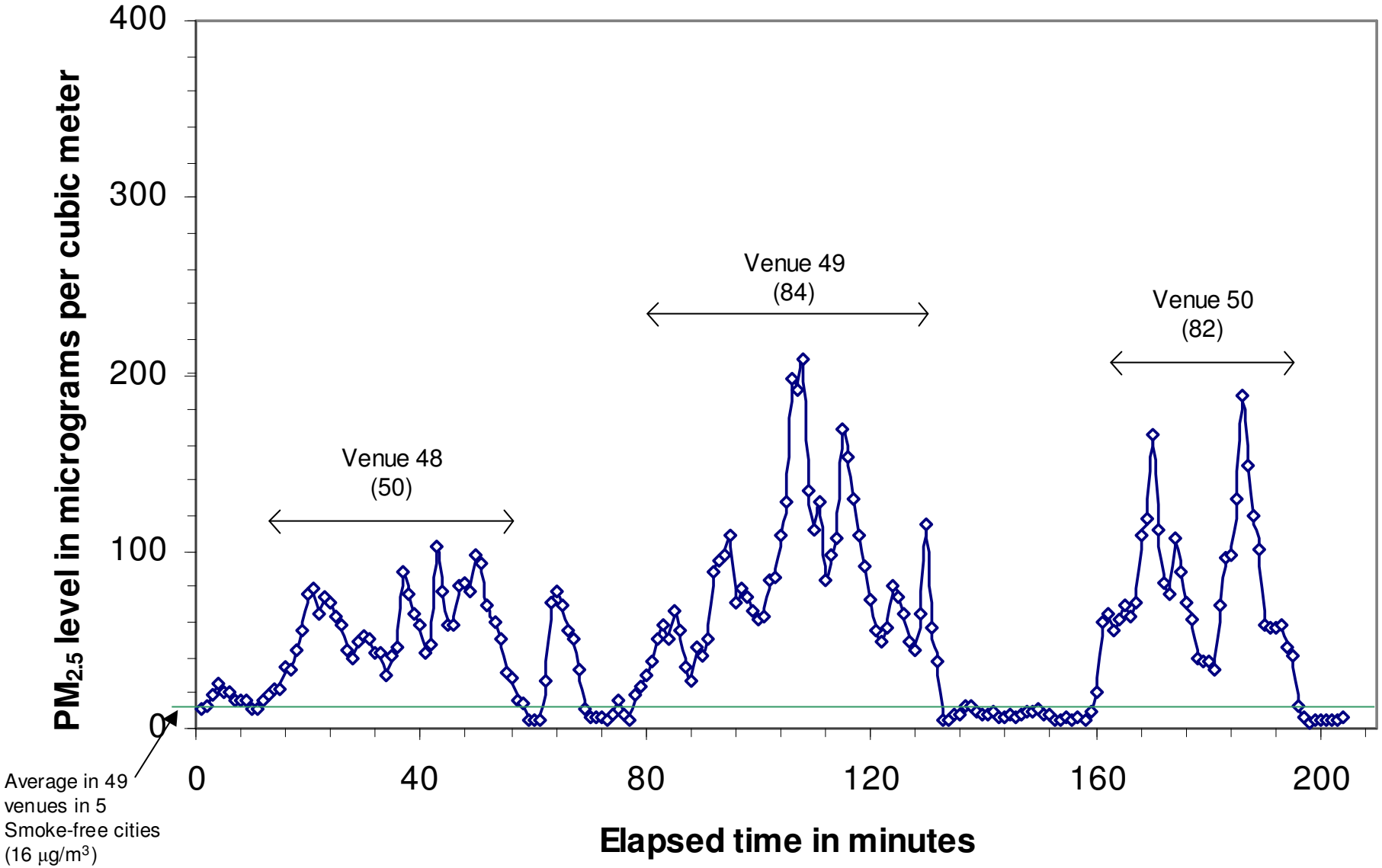


Figure 11

Charleston County, SC, Air Monitoring Study
April 4th, 2006

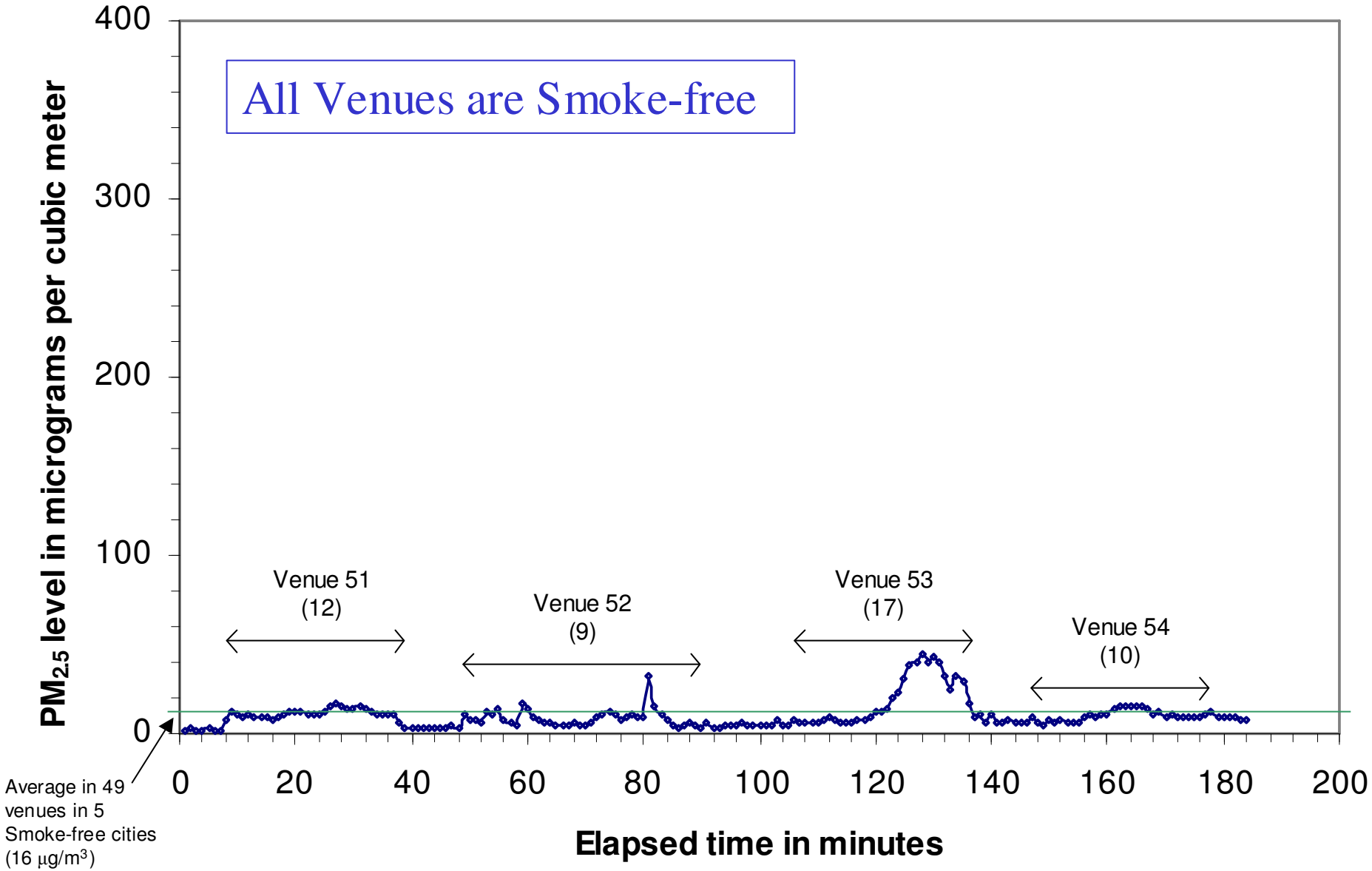


Figure 12

Charleston County, SC, Air Monitoring Study
April 4th, 2006

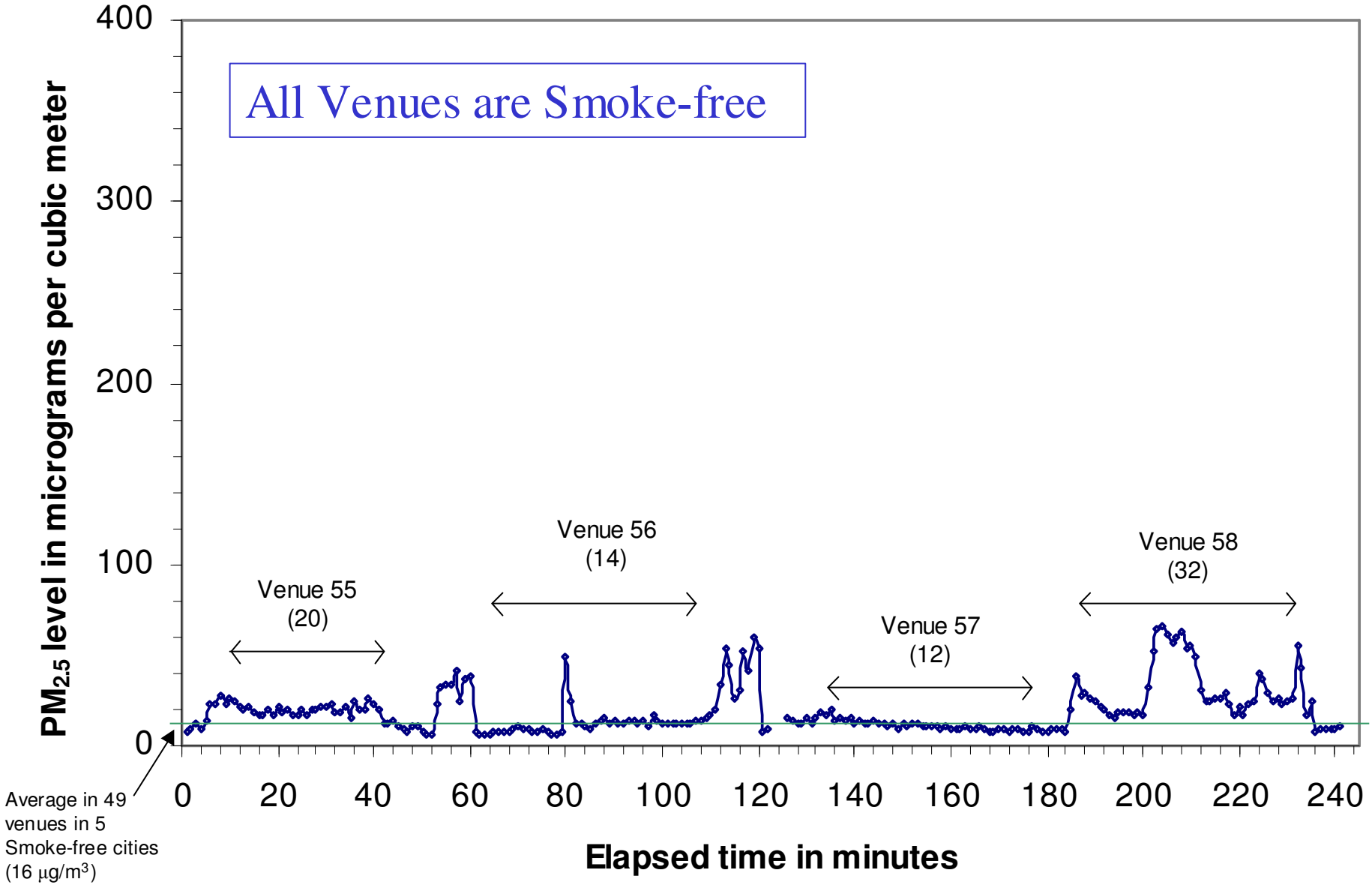
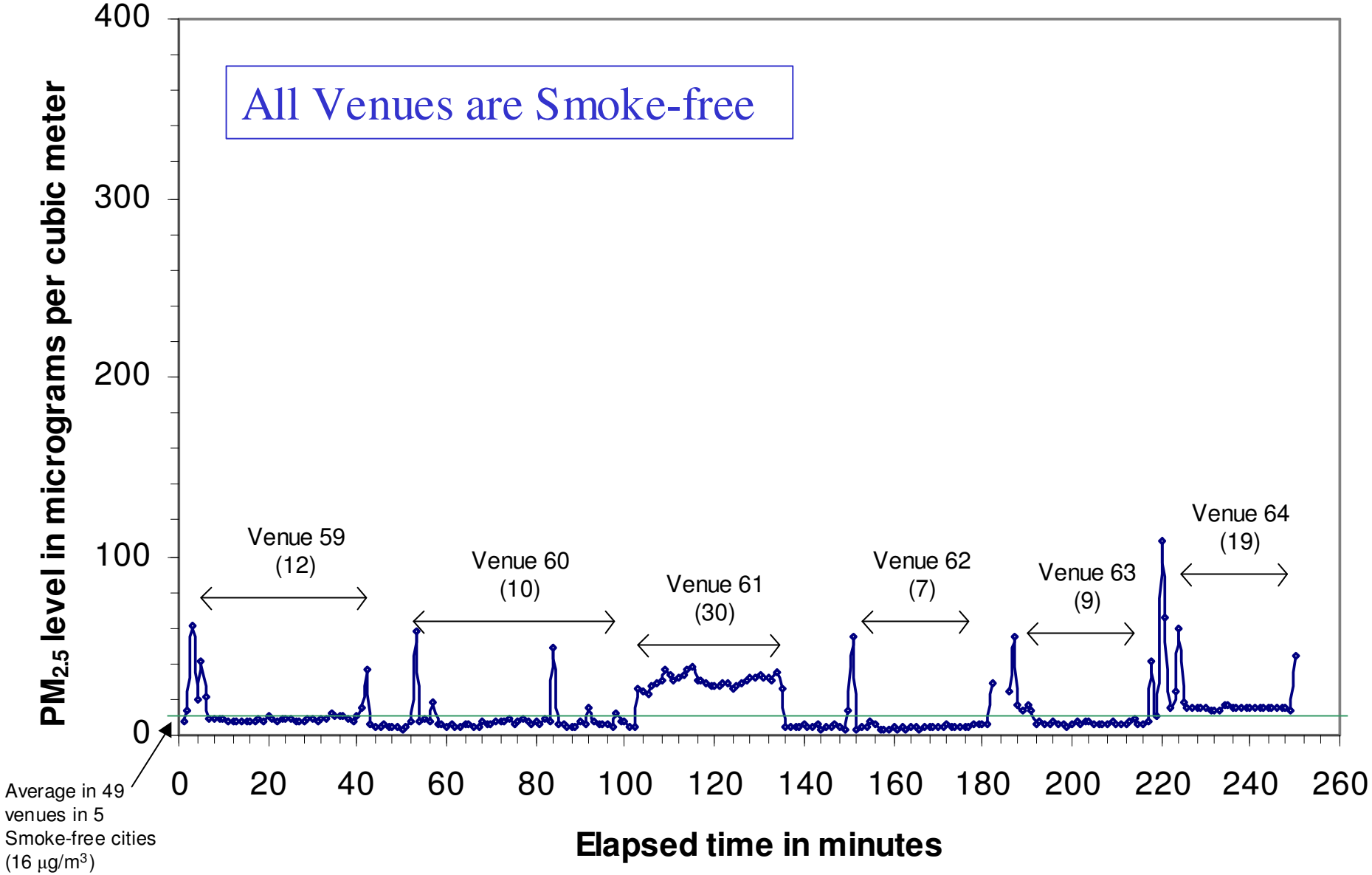


Figure 13

Charleston County, SC, Air Monitoring Study
April 5th, 2006



Discussion

The EPA cited over 80 epidemiologic studies in creating a particulate air pollution standard in 1997.[7] In order to protect the public health, the EPA has set limits of 65µg/m^3 within a 24-hour period, as well as 15 µg/m^3 as the average annual level of PM2.5 exposure. The average PM2.5 level across all locations sampled in Charleston County, SC, where smoking was allowed was 260µg/ m^3. For full-time employees in these venues, their average annual PM2.5 exposure would be 59µg/ m^3 (assuming exposure to 260 µg/ m^3 on the job, exposure to zero particles off the job, and a 40 hour work week). The EPA average annual PM2.5 limit is exceeded by 4 times due solely to their occupational exposure. Based on the latest scientific evidence, the EPA staff currently proposes even lower PM2.5 standards to adequately protect the public health,[8] making the high PM2.5 exposures of people in smoking environments even more alarming.

Previous studies have evaluated air quality by measuring the change in levels of respirable suspended particles (RSP) between smoke-free venues and those that permit smoking. Ott et al. did a study of a single tavern in California and showed an 82% average decrease in RSP levels after smoking was prohibited by a city ordinance.[9] Repace studied 8 hospitality venues in Delaware before and after a statewide prohibition of smoking in these types of venues and found that about 90% of the fine particle pollution could be attributed to tobacco smoke.[10] Similarly, in a study of 22 hospitality venues in Western New York, Travers et al. found a 90% reduction in RSP levels in bars and restaurants, and 84% reduction in large recreation venues such as bingo halls and bowling alleys, and even a 58% reduction in locations where only SHS from an adjacent room was observed at baseline.[11] A cross-sectional study of 53 hospitality venues in 7 major cities across the U.S. showed 82% less indoor air pollution in the locations subject to smoke-free air laws, even though compliance with the laws was less than 100%.[12]

Other studies have directly assessed the role SHS exposure has on human health. One study found that respiratory health improved rapidly in a sample of bartenders after a state smoke-free workplace law was implemented in California,[13] and another study reported a 40% reduction in acute myocardial infarctions in patients admitted to a regional hospital during the 6 months that a local smoke-free ordinance was in effect.[14] The effects of even brief (minutes to hours) passive smoking on the cardiovascular system are often nearly as large (averaging 80% to 90%) as chronic active smoking. The effects of secondhand smoke are substantial and rapid, explaining the relatively large health risks associated with secondhand smoke exposure that have been reported in epidemiological studies.[12] Farrelly et al. also showed a significant decrease in both salivary cotinine concentrations and sensory symptoms in hospitality workers after New York State's smoke-free law prohibited smoking in their worksites.[15]

The hazardous health effects of exposure to secondhand smoke are now well-documented and established in various independent research studies and numerous international reports. The body of scientific evidence is overwhelming: there is no doubt within the international scientific community that secondhand smoke causes heart disease, lung

cancer, nasal and sinus cancer, sudden infant death syndrome (SIDS), asthma and middle ear infections in children and various other respiratory illnesses. Secondhand smoke exposure is also causally associated with stroke, low birthweight, spontaneous abortion, negative effects on the development of cognition and behavior, exacerbation of cystic fibrosis, and cervical cancer.

Conclusions

Hospitality venues allowing indoor air smoking in Charleston County, SC, are significantly more polluted than both indoor smoke-free sites and outdoor air. Workers in the locations sampled in this study are exposed to pollution levels more than 4 times higher than the annual EPA exposure standard for fine particle air pollution in place to protect the public health. This study demonstrates that workers and patrons are exposed to harmful levels of a known carcinogen and toxin. Policies that prohibit smoking in public worksites dramatically reduce secondhand smoke exposure and improve worker and patron health.

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