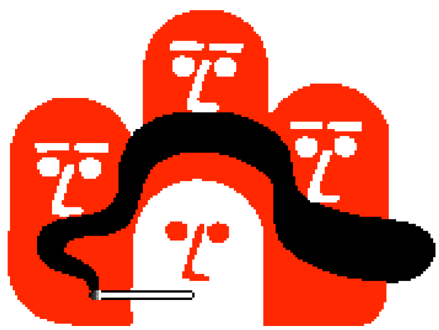
AIR POLLUTION IN VIRGINIA'S HOSPITALITY INDUSTRY

James L. Repace, MSc.
Repace Associates, Inc.
Secondhand smoke Consultants
101 Felicia Lane, Bowie, MD 20720

301-262-9131 phone; 301-262-3865 fax; email: repace@comcast.net; website: www.repace.com.

January 10, 2006 Final Report

A report prepared for
Virginians for a Healthy Future
1001 E. Broad Street, Suite 225
Richmond, VA 23219 (804) 497-3151



Abstract

Air quality was monitored in 12 hospitality venues in Virginia (11 smoking and 1 nonsmoking), in 19 outdoor locales, and 5 highway locations located in Richmond, Roanoke City, Dale City, Fredericksburg, and Virginia Beach. Referred to the U.S. Air Quality Index for Particulate Matter pollution ($PM_{2.5}$), indoor air quality was Code Green (Good) in the single nonsmoking venue, in all outdoor and transit-related locales (city streets, I-95, Powhite Parkway toll booth), and was Code Yellow (Moderate) in the Hampton Roads Tunnel on the upgrade. However, in the smoking venues, air pollution from secondhand smoke (SHS) reached as high as 18 times the level in the Hampton Roads Tunnel to Hazardous (Code Maroon) air pollution emergency levels in one bar, and pollution was at Code Violet (Very Unhealthy) levels in a bingo hall, bowling alley, and 2 pubs, Code Red (Unhealthy) in a bar and 2 pubs, and Code Yellow (Moderate) in 3

restaurants. Virginia's hospitality industry is delivering highly polluted air to its workers and patrons. Tobacco smoke pollution in Virginia is not being – and cannot be -- controlled by ventilation or air cleaning technology, and is a clear and present danger to the health of hospitality workers and patrons. While Virginia regulates outdoor air so that 90% of its counties deliver safe outdoor air to the public, the State has failed to regulate the quality of its indoor air in its workplaces and public spaces. For the health and safety of its workforce, and for the protection of the 8 out of 10 adult Virginians who do not smoke, Virginia should enact a statewide smoke-free workplace law, as have 7 other States, or at least stop pre-empting local control over indoor air pollution in the workplace.

The Air Quality Index (AQI) Color Code

http://cfpub.epa.gov/airnow/index.cfm?action=static.aqi

Downloaded 1/7/06

AQI colors

EPA has assigned a specific color to each AQI category to make it easier for people to understand quickly whether air pollution is reaching unhealthy levels in their communities. For example, the color orange means that conditions are "unhealthy for sensitive groups," while red means that conditions may be "unhealthy for everyone," and so on.

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0-50	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	51-100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101-150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151-200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201-300	Health alert: everyone may experience more serious health effects.
Hazardous	> 300	Health warnings of emergency conditions. The entire population is more likely to be affected.

AIRNow is a government-backed program. Through AIRNow, EPA, NOAA, NPS, news media, tribal, state, and local agencies work together to report conditions for ozone and particle pollution. State, Local and Tribal Partners.

{see also: http://cfpub.epa.gov/airnow/index.cfm?action=airnow.main}

About the author: J.L. Repace, MSc., Biophysicist

I was asked to analyze air quality data collected by Virginians for a Healthy Future and to write this summary report on its results. I am president of Repace Associates, Inc., Secondhand Smoke Consultants, a Maryland Corporation. Since March 1998, I have been an international consultant on secondhand smoke (SHS), also known as environmental tobacco smoke (ETS). I have published 77 scientific papers, 69 of which concern the hazard, exposure, dose, risk, and control of SHS. I have received numerous awards, including the Surgeon General's Medallion from Dr. C. Everett Koop, the Cahan Distinguished Professor Award from the Flight Attendant Medical Research Institute, the Innovator Award from the Robert Wood Johnson Foundation, and a Lifetime Achievement Award from the American Public Health Association. I am also a visiting Assistant Clinical Professor at the Tufts University School of Medicine. I have consulted on SHS throughout the U.S. and Canada, as well as in many foreign countries.

From February 1979 to September 1986, I served as a senior policy analyst in the Office of Air and Radiation at the U.S. Environmental Protection Agency (EPA) in Washington, DC. on the science policy staff of the Assistant Administrator in charge of the nation's air programs. From September 1986 to February 1998, I served as a senior policy analyst in the Indoor Air Division. During my tenure, I also served for periods of the order of one year on detail as a staff scientist to the EPA's Office of Research and Development, and to the U.S. Department of Labor's Occupational Safety and Health Administration (OSHA). From 1963 to 1979, I held consecutive posts at the Grasslands and Delafield Hospitals in New York as a Health Physicist, at the RCA Sarnoff Laboratory in Princeton, New Jersey, as a Research Associate, and as a Research Physicist in the Ocean Sciences and Electronics Divisions at the Naval Research Laboratory in Washington, DC. I earned the BSc. (1962) and MSc. in Physics (1968) from the Brooklyn Polytechnic Institute (now Polytechnic University), in New York City. My full Curriculum Vitae is posted on www.repace.com.

Introduction

Secondhand smoke (SHS) contains nearly 5000 chemical compounds, at least 172 of which are known toxic substances, containing 33 Hazardous

Air Pollutants (HAP), 47 Chemicals restricted as Hazardous Waste (HW) and 67 Known Human or Animal Carcinogens. 3 additional chemicals or mixtures in SHS are EPA-regulated Criteria Pollutants (Repace, in press). Exposure to SHS is a known cause of disease, according to a number of lengthy, authoritative, peer-reviewed reports by national and international environmental, occupational, and public health authorities. The Surgeon General (SG 1986), the National Academy of Sciences (NRC, 1986), the International Agency for Research on Cancer (IARC, 1987, 2004), the National Institute for Occupational Safety and Health (NIOSH 1991), the Environmental Protection Agency (EPA 1992), the Occupational Safety & Health Administration (OSHA, 1994), the National Cancer Institute (NCI 1993, 1998, 1999), the California EPA (Cal EPA 1997, 2005), and the National Toxicology Program (NTP 2000), variously concluded that nonsmokers' exposure to SHS causes fatal heart disease, lung, breast, and nasal sinus cancer, asthma induction and aggravation, middle ear infection, sudden infant death syndrome, and respiratory impairment, as well as irritation of the mucous membranes of the eyes, nose, and throat. SHS is now widely accepted as the third leading preventable health hazard after active smoking and alcohol (SG, 2004), producing about 50,000 deaths per year in the U.S. (CalEPA, 2005); nevertheless it continues to be a widespread indoor pollutant in many states in the U.S. and abroad.

One of the most important sources of exposure to air pollution from SHS is the hospitality industry: bars, restaurants, nightclubs, bowling alleys, and gaming facilities such as bingo games and casinos. Indoor air pollution from SHS in such venues has historically been investigated using air quality monitors (Repace and Lowrey, 1980; Ott et al., 1996, Repace, 2004; Travers et al, 2004). Recent air monitoring studies of SHS in 6 bars in Wilmington, Delaware, and in 14 bars in 3 counties in western New York State, before and after state-wide clean indoor air laws, found that SHS contributes about 90% of the respirable particles (RSP) and carcinogenic particulate polycyclic aromatic hydrocarbons (PPAH) air pollution in bars (Repace, 2004). Measured levels greatly exceeded levels of these contaminants encountered on major truck highways and polluted city streets. The RSP levels from SHS in these venues *de facto* violated the U.S. Annual National Ambient Air Quality Standard (NAAQS) for fine particulate matter, generating significant health risks for bar staff (Repace, 2004; Travers et al., 2004).

The U.S. Annual National Ambient Air Quality Standard (NAAQS) for RSP. To place RSP into perspective, consider the NAAQS for particulate matter 2.5 microns in diameter or less ($PM_{2.5}$). $PM_{2.5}$ is the RSP size range that encompasses combustion-related fine particulate by-products such as tobacco smoke, chimney smoke, and diesel exhaust. $PM_{2.5}$ is legally regulated in the outdoor air. In 1997, the EPA promulgated a 24-hour NAAQS for $PM_{2.5}$ of 65 $\mu g/m^3$, also limited by an annually averaged NAAQS for $PM_{2.5}$ of 15 $\mu g/m^3$, based on protecting human health. The NAAQS for $PM_{2.5}$ is designed to protect against such respirable particle health effects as premature death, increased hospital admissions, and emergency room visits (primarily the elderly and individuals with cardiopulmonary disease); increased respiratory symptoms and disease (children and individuals with cardiopulmonary disease); decreased lung function (particularly in children and individuals with asthma); and against alterations in lung tissue and structure and in respiratory tract defense mechanisms in all persons (EPA, 1997). 90% of U.S. Counties have PM2.5 levels below about 16 $\mu g/m^3$ (Figure 1).

Air Quality forecasts are provided by State and local agencies, using the U.S. Environmental Protection Agency's (EPA) Air Quality Index (AQI), a uniform index that provides general information to the public about air quality and associated health effects (EPA, 1999). These index descriptors are described in Table 1. Health advisories and warnings are based on the current AQI as well as the forecasted AQI. Air quality authorities maintain running averages for each pollutant, and an appropriate AQI is reported that generally corresponds to the current average. For most major cities, air quality forecasts, based on predicted meteorological conditions and monitored air quality, are also released to the public usually during the afternoon hours of the day preceding the forecast period. These forecasts are for PM and ozone, since these are the pollutants that generally contribute to unhealthy air quality. If pollutant levels are expected to be unhealthy, the state and local agencies will release a color-coded health warning or advisory to the local media and post these advisories on their web sites (Ellsworth, 2005). The color codes and corresponding normalized Air Quality Indices are based upon "break-points" or ranges of minimum-to-maximum particulate levels corresponding to increasing severity of expected health effects, and are shown in Table 1. Note that the AQI is not linearly related to $PM_{2.5}$. In many U.S. communities, AQI values are usually below 100, with values greater than 100 occurring at most several times a year. Typically, larger cities have more severe air pollution problems, and the AQI in these areas may exceed 100 more often than in smaller cities. AQI values higher than 200 are infrequent, and AQI values above 300 are extremely rare (Ellsworth, 2005).

Table 2 shows that 9 counties in Northern Virginia, 10% of Virginia's counties, were designated as "non-attainment" for national ambient (outdoor) air quality standards in 2004 (Letter from M. Leavitt, Administrator, US EPA, to Gov. Mark Warner, VA, Dec. 17, 2004). Of the locales sampled in this study, only Dale City (Prince William) is in a non-attainment area. Non-attainment areas have annual outdoor air $PM_{2.5}$ averages greater than 15 micrograms per cubic meter ($\mu g/m^3$) NAAQS as shown in Figure 1. 90% of Virginia's counties attain the NAAQS for $PM_{2.5}$.

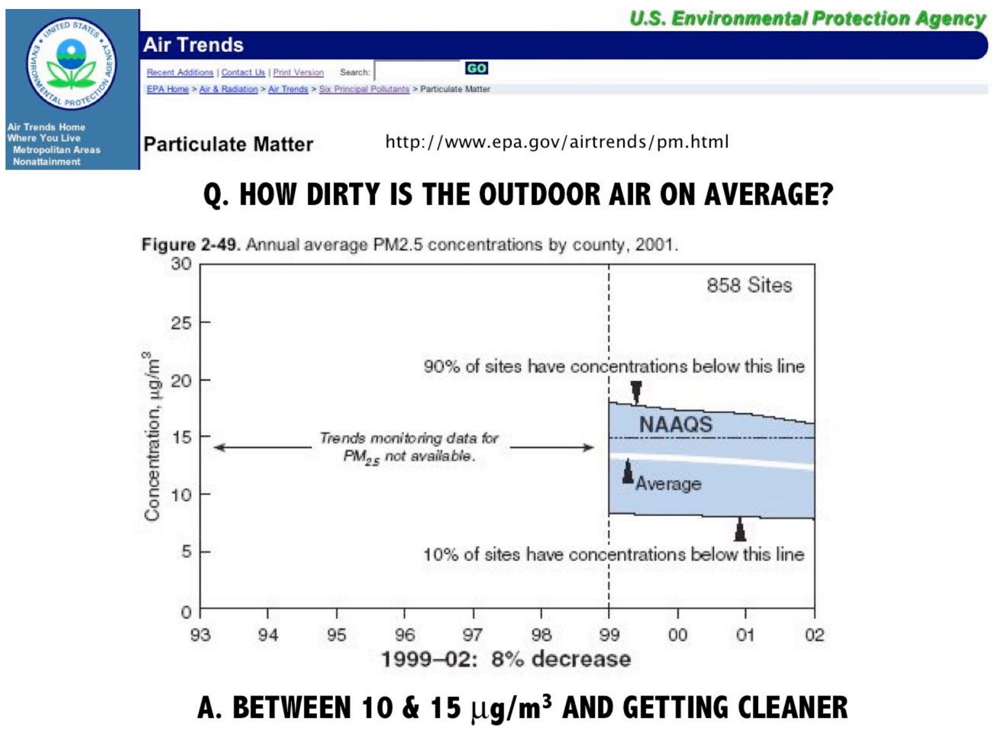


FIGURE 1. 90% of U.S. Counties have annual average outdoor air $PM_{2.5}$ concentrations below about 16 $\mu g/m^3$, due to outdoor clean air laws.

Table 1. Levels of fine particulate ($PM_{2.5}$) air pollution in units of micrograms per cubic meter (($\mu g/m^3$) and corresponding U.S. health advisory descriptors with accompanying simplified color code (USEPA, 1999).

$PM_{2.5}$ ($\mu g/m^3$) AQI Break-points	Air Quality Index	Category	Color Code
0.0 - 15.4	0 - 50	Good	Green
15.5- 40.4	51 - 100	Moderate	Yellow
40.5 - 65.4	101 -150	Unhealthy SG*	Orange
65.5 - 150.4	151 - 200	Unhealthy	Red
150.5 - 250.4	201 - 300	Very unhealthy	Violet
250.5 - 350.4	301 - 400	Hazardous	Maroon
350.5 - 500.4	401- 500	Very Hazardous	Maroon
> 505	500	(Significant Harm)	**

*SG = sensitive groups; **exists, but is not a part of the AQI as outdoor air never gets this polluted due to federal and state regulation and enforcement action (Ellsworth, 2005).

Table 2. U.S. EPA 2004 Air Quality Nonattainment Areas in Virginia

State	Area Name	Counties
Virginia	Washington, DC-MD-VA	Alexandria
		Arlington
		Fairfax
		Loudoun
		Prince William
		Falls Church
		Manassas
		Manassas Park
		Fairfax City

Appendix B shows the quarterly average and peak quarterly readings for Virginia's counties. The highest peak value was 42 micrograms per cubic meter ($\mu g/m^3$) for $PM_{2.5}$ in Fairfax County. The State of Virginia regulates outdoor air pollution under the Virginia Code: § 10.1-1308. Regulations, which specifies in part that: "A. The Board, after having studied air pollution in the various areas of the Commonwealth, its causes, prevention, control and abatement, shall have the power to promulgate regulations, including emergency regulations, abating, controlling and prohibiting air pollution throughout or in any part of the Commonwealth in accordance with the provisions of the Administrative Process Act (§ 2.2-4000 et seq.) … The regulations shall not promote or encourage any substantial degradation of present air quality in any air basin or region which has an air quality superior to that stipulated in the regulations." However, these regulations, like those of the Federal Clean Air Act, have been interpreted to apply only to the quality of the outdoor air. Since people spend 90% of their time indoors, the quality of pubic space indoor air is an important determinant of an individual's air pollution burden (Repace, in press).

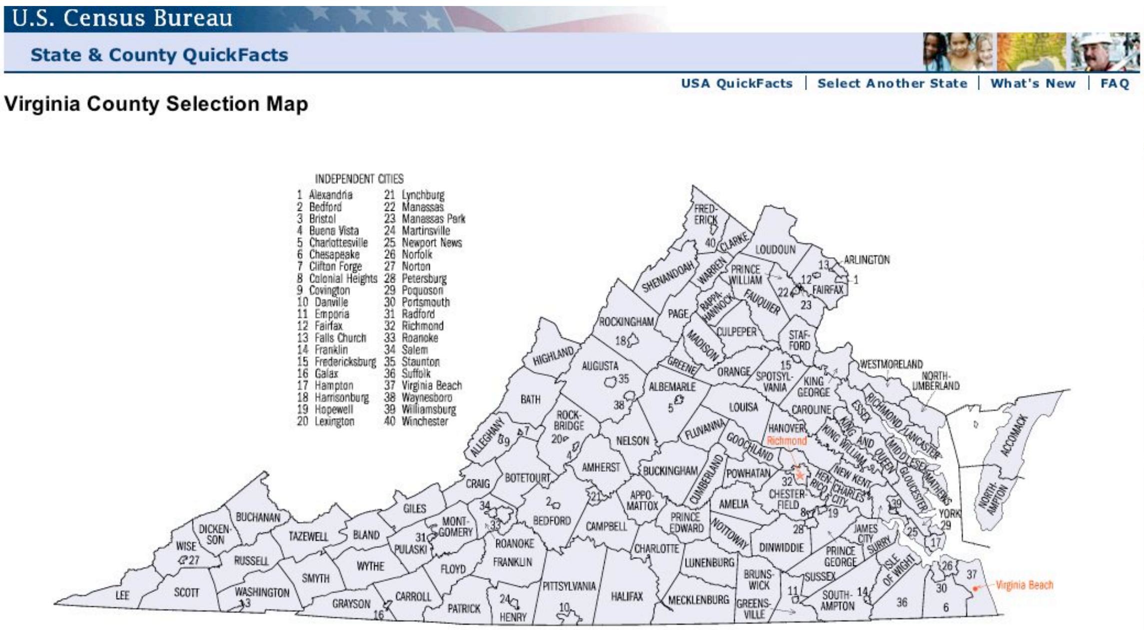


Figure 2. Location of Venues in Cities within Counties sampled in Virginia.

This report is an analysis of $PM_{2.5}$ respirable particle data collected using the TSI SidePak, Figure 3. (TSI, Inc., 500 Cardigan Road, Shoreview, MN 55126-3996 U.S.A.)

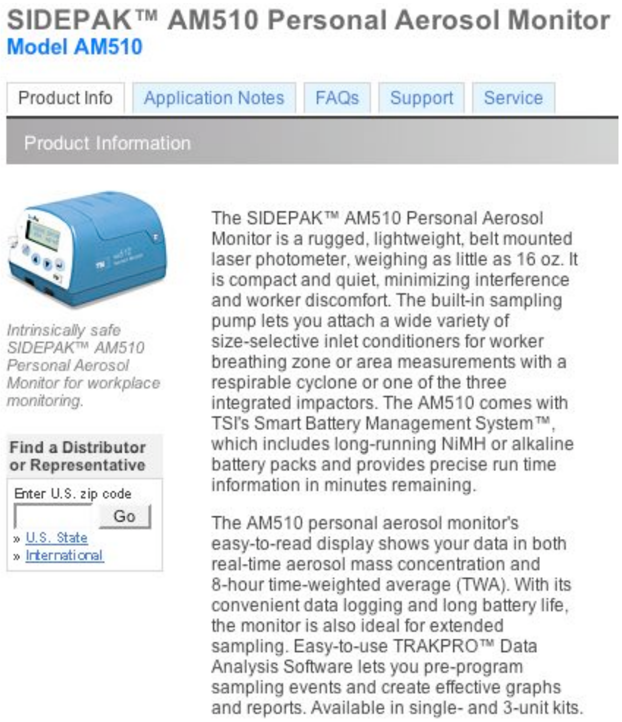


Figure 3. The TSI SIDEPAK used in the Virginia air quality study.

The measured RSP levels were compared to State health advisory indices based on the color-coded federal outdoor Air Quality Index (AQI). RSP is taken to be the same as $PM_{2.5}$. $PM_{2.5}$ consists generally of combustion-generated airborne particles with a mass-median diameter of 2.5 micrometers and below, the size range which can penetrate deep into the lung to the level of the terminal bronchioles and has prolonged residence times (USEPA, 1999). These particles are so small they can be detected only with an electron microscope. Sources of fine particles outdoors include all types of combustion, including motor vehicles, power plants, residential wood burning, forest fires, agricultural burning, and some industrial processes. Indoors, sources of fine particles include smoking, cooking, and fireplaces.

Methods.

Instrument Calibration.

1. The SidePak monitor used in this field survey of RSP was loaned to Virginians for a Healthy Future by the University of Kentucky. The SidePak was calibrated by Kiyoung Lee, PhD., at the University of Kentucky. The SidePak was calibrated as follows (Lee K, 2005, personal communication). Fine particle concentrations were measured using a continuous particle monitor (SidePak, TSI, MN). The SidePak monitor

draws air through a sensor that measures particles based on light scattering. A 2.5 µm impactor can be attached to inlet of the monitor. The particle mass data are measured as $PM_{2.5}$ and stored in a data logger. The stored data was downloaded to a computer after the monitoring. The SidePak monitor was calibrated against a gravimetric measurement of $PM_{2.5}$ in a series of laboratory experiments to ensure accuracy. Gravimetric measurements are the gold standard in particle measurements. The SidePak monitor was placed in a chamber along with the Personal Environmental Monitor (PEM for $PM_{2.5}$, MSP). PEM removes particles larger than 2.5 µm using impaction and collects $PM_{2.5}$ on filter paper. The PEM sampler was operated at 4 liters per minute and flow rate was calibrated before and after the sampling using a flow rate calibrator (Model 4100, TSI). The pre-weighed filter was dried and re-weighed with a microbalance (Cahn, Thermo). A total of 14 calibration tests were conducted using a smoking chamber with secondhand tobacco smoke. During the chamber experiment, relative humidity ranged from 45-50% and temperature from 21°C to 24.5°C. The cigarettes (Marlboro, medium) were smoked at a rate of a 2-s, 35-ml puff each minute using a 30-port Heiner Borgwaldt Smoking Machine (Hamburg, Germany). Only secondhand tobacco smoke was introduced to the 0.7 m^3 Hinners-type stainless steel/glass exposure chamber.

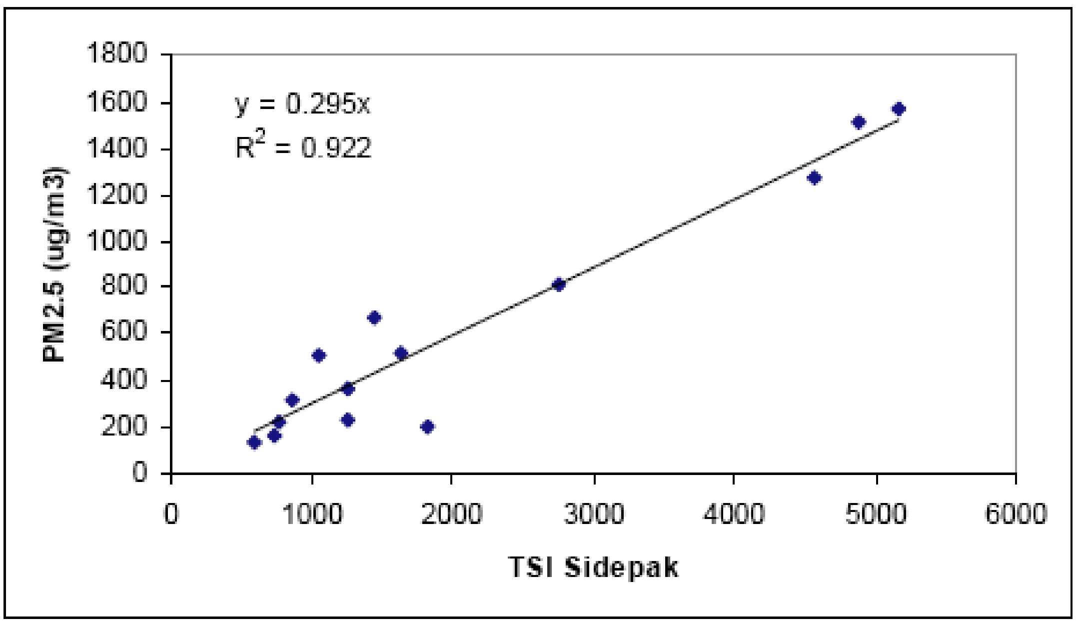


Figure 4. Calibration of the SidePak against gravimetric $PM_{2.5}$. Both axes in units of micrograms per cubic meter (Lee K, Univ. of KY, personal communication).

Sampling Methodology.

The air quality survey was performed by the staff and volunteers of Virginians for a Healthy Future. Fine particle ($PM_{2.5}$) air pollution levels using the SidePak personal air monitor were measured in 12 restaurant/bar venues (eleven smoking-permitted, one smoke-free) in the State of Virginia, in Richmond (Hanover), Roanoke City (Roanoke), Dale City (Prince William), Fredericksburg (Spotsylvania), and Virginia Beach (Princess Anne), in 19 outdoor locations, and in 5 transit-related locations, including 3 on I-95 in Prince William, the Powhite Extension toll booth in Richmond, and the Hampton Roads Tunnel (Princess Anne) (Figure 2). The sampling methodology was conducted according to standard protocols for measuring SHS (Repace, 1987; 2004). The TSI SidePak was calibrated before each day's test, started before entering the venue to capture outdoor data, run during the venue visit and then approximately five minutes upon leaving the venue. If several venues were tested on the same day, the equipment remained in operation during the full day's run. Field volunteers kept a time-activity pattern diary in which they recorded the name of each venue or location, and the time when each venue was entered and exited. Inside each venue, they recorded at approximately 10 minute intervals the number of people and the number of burning cigarettes observed. Field personnel were asked to provide at least thirty minutes of observations within each venue, to record the length, width, and height of each venue using an electronic ruler. Photos were taken of all the venues, notations were made of any observations that could be helpful to the analysis.

Theory -- The SHS-RSP Habitual Smoker Model

Concentrations of SHS are directly proportional to the smoker density and inversely proportional to the air exchange rate. Thus, at fixed air exchange and smoking rates, one cigarette smoked in a large room will yield a lower SHS concentration than one smoked in a small room. However, by measuring concentration and smoker density, it is possible to normalize for this effect and generalize the results. Smoker density can be determined by measuring the average number of cigarettes smoked during the observation time, and dividing by the space volume. The total or "effective" air exchange rate, is defined as the sum of pollutant removal by ventilation, surface deposition, and air cleaning (if any).

Air Exchange Rates: Restaurants and bars use forced-air mechanical ventilation to provide heating, cooling, and ventilation air. Mechanical ventilation rate design values are specified by the Atlanta, GA,-based American Society of Heating, Refrigeration, and Ventilation Engineers (ASHRAE, 1989, 2004). Assuming most of the venues investigated are 10 or more years old, the ventilation systems would have been designed according to ASHRAE Standard 62-1989, *Ventilation for Acceptable Indoor Air Quality*, specified ventilation rates for odor control "to accommodate a moderate amount of smoking" for premises in which smoking was allowed. These design ventilation rates are based upon building occupancy, i.e., number of occupants per unit floor area. For a given smoking prevalence, this determines the number of smokers per unit floor area, and for a given ceiling height, the smoker density. Thus, for a specific venue, e.g., a bar, the default design occupancy from the ASHRAE Standard can be used to estimate both the smoker density and the ventilation air exchange rate. Assuming a 10-foot ceiling, the default design air exchange rate for a bar is: C_v = (30 ft^3/min-occ)(100 occ/10,000 ft^3)(60 min/hr) = 18 air changes per hour (h^{-1}). The current edition of this standard, ASHRAE 62.1-2004, recommends ventilation rates only for non-smoking buildings, because cognizant authorities have condemned SHS as a cause of mortality.

The Habitual Smoker Model (HSM) (Equation 1) is used to predict SHS concentrations, or to estimate the air exchange rate of a venue if the smoker density and SHS-RSP concentration are measured. This model is described in Repace (2004). Equation 1 gives the SHS-RSP concentration, in units of micrograms of pollutant per cubic meter of air ($\mu g/m^3$), as a function of the active smoker density D_s, in units of average number of burning cigarettes per hundred cubic meters (BC/100m^3) in the building and the air exchange rate C_v, in units of air changes per hour (h^{-1}):

$$RSP_{ETS} = 650\frac{D_s}{C_v} \quad (\mu g/m^3) \qquad \textbf{(Eq. 1).}$$

Predicted Active Smoker Density, D_s: The number of active smokers is defined as the number of burning cigarettes encountered in a venue averaged over the observation time, when counted every ten minutes, which is the approximate time a cigarette is smoked. The active smoker density is the number of burning cigarettes divided by the space volume expressed in metric units of hundred cubic meters. Virginia smoking prevalence* in 2004 was: Men, 22.4% (95% CI: ± 2.4%), Women, 19.5% (±1.9%), All, 20.9% (± 1.5%) By comparison, the U.S. average in 2004 was: 20.9%, 23.4% in men and 18.5% in women. (MMWR, 2004) [* Persons aged >18 years who reported having smoked >100 cigarettes during their lifetime and who currently smoke every day or some days.] If a Virginia bar has a percentage of smokers equal to the 2004 smoking prevalence of 20.9%, the default habitual smoker density is (0.209 smokers/occupant)(100 occupants/10,000 ft^3) = 20.9 smokers per 10,000 ft^3, or in metric units, 20.9 smokers per 283 cubic meters (m^3), of whom 1/3 would be expected to be actively smoking at any one time, which yields a predicted active smoker density at full occupancy of $D_s = (1/3)(20.9)/2.83 = 2.46$ active smokers per 100 m^3. This number is the default smoker density against which the actual smoker density can be compared to generalize the data measured in the study.

Using Eq. 1, the predicted respirable smoke particulate (RSP) concentration ($PM_{3.5}$) for a Virginia bar under the ASHRAE default assumptions for occupancy and ventilation, and the 2004 Virginia smoking prevalence is calculated as:

$$\text{SHS-RSP}_{pub} = 650(2.46)/(18) = 89\ \mu g/m^3.$$

Assuming a background RSP concentration of 7 $\mu g/m^3$ from outdoor non-SHS sources infiltrating indoors (see below), a field study of fine particle pollution from smoking in the ASHRAE-default occupied and ventilated pub (full occupancy, average smoking prevalence, and ASHRAE Standard ventilation rate) might be expected to show an estimated total RSP concentration of about (89 + 7) = 96 $\mu g/m^3$ with the RSP background added. Using the 15 $\mu g/m^3$ level of the U.S. National Ambient Air Quality standard as a reference level for "Clean Air," the Clean Air reference level is exceeded by a factor of (96/15) = 6.4. In other words, in a bar at full occupancy at Virginia State smoking prevalence, and using the ventilation rate specified by the building code, clean air cannot possibly be attained.

More generally, these predictions will serve as ball-park numbers to expect in this field study, and as a basis for generalizing the results of the field study to similar venues that may have different smoker densities or air exchange rates. If the smoker density in a particular venue is lower -- or the air exchange rate higher -- than the default calculation, the actual concentration will be lower; if the smoker density is higher or the air exchange rate lower, the actual concentration will be higher.

Results.

Table 3 compiles the data for recorded by the field staff for the venue, area, ceiling, volume, person count, area person density, burning cigarette averages, and sampling time; the estimated smoker prevalence; the measured indoor, outdoor, and in-transit RSP data recorded by the SidePak; the air quality index value associated with the measured indoor RSP levels; the active smoker density, and the air exchange rate as estimated by Equation 1. Figure 5 shows a plot of the indoor/outdoor/in-transit levels for all locations and venues. Figure 6 compares the summary means for all locations and venues with the Federal Air Quality Index (AQI). The mean of the indoor smoking venues at 178 $\mu g/m^3$, is far greater than the RSP pollution level in transit, outdoors, and in the single indoor nonsmoking venue, as well as a factor of (178/36) = 5 times as high as the level in the Hampton Roads Tunnel. Figure 7 gives a log-probability plot giving the cumulative frequency distribution for all 11 indoor smoking venues, and shows the log-normally distributed data and goodness of fit (R^2 = 0.95), with a median value of 116 $\mu g/m^3$ for all venues. The Occupational Safety and Health Administration's (OSHA) Significant Risk Level of 1 death per 1000 workers per working lifetime of 45 years is shown for comparison, indicating that all 11 venues violated this level. For the bars, the RSP levels ranged from 83 to 680 $\mu g/m^3$; and none was even close to full occupancy. All venues had less than expected air exchange rates. Figure 8 contrasts the Virginia data with the Delaware Hospitality Venues, pre-and-post a state-wide workplace smoking ban, showing that Delaware had very similar air pollution levels in its hospitality venues prior to going smoke-free.

Discussion

In 1994, OSHA announced a proposed rule to ban smoking in all workplaces, estimating that as many as 13,000 nonsmoking workers died annually due to passive smoking on the job (OSHA, 1994). However, because of repeated Congressional insistence that SHS is an issue best handled by the States, OSHA was discouraged from proceeding with this rulemaking. However, although Massachusetts, Rhode Island, New York, Delaware, South Dakota, Montana, and California, have passed totally smoke-free workplace legislation (Americans for Nonsmokers Rights Foundation, Oct. 4, 2005), the remainder of the States have been slow to take action, especially in the hospitality industry sector. This study exemplifies the consequences of this inaction, which rises to the level of malfeasance. Among the 12 indoor venues, only the single nonsmoking restaurant had Good air quality. For the remainder, 3 were Moderate, 3 were Unhealthy, 4 were Very Unhealthy, and one, the air quality was consistent with the Significant Harm to human health. As Figure 7 shows, every single one of the 11 smoking venues had air so polluted from SHS that OSHA's Significant Risk of Material Impairment of Health level was exceeded. Thus, Virginia's failure to enact a statewide smoke-free workplace law or even to permit local control over clean indoor air for Virginia's communities has grave consequences for its nearly 4 million workers, and especially its 325,000 leisure and hospitality workers (Bureau of Labor Statistics, U.S. Dept. of Labor, 2006).

Moreover, Junker et al. (2001), conducted a study aimed at determining air quality standards required to protect nonsmokers from adverse health effects caused by impacts of SHS from smoldering cigarettes on the human sensory system as well as to provide measures for establishing acceptable indoor air quality. Junker et al. (2001) found that that the threshold for objectively measured sensory irritation of 4.4 $\mu g/m^3$ for $PM_{2.25}$, and that at this level, 67% of the subjects judged the quality of the air to be unacceptable. These authors concluded that the results for sensory symptoms show that even at very low SHS concentrations, subjects perceived a significant increase in sensory impact (eye, nasal, and throat irritation), and felt significantly more annoyed and reported the quality of the air to be less acceptable than exposure to zero levels of SHS. If in table 3, the non-SHS $PM_{2.5}$ background of 3.5 $\mu g/m^3$ is subtracted from the most-polluted venue, Pub D in Roanoke, the SHS $PM_{2.5}$ level in Pub D exceeds Junkers' irritation threshold by a factor of (680-3.3)/4.4 = 154-fold, and if this calculation is performed for the least SHS-polluted venue, Restaurant B in Richmond, the irritation ratio is still (21-5.3)/4.4 = 3.7 times the threshold. Thus, as Figure 7 shows graphically, every single one of the 11 venues studied in this report exceeded the 4.4 $\mu g/m^3$ irritation threshold by factors ranging from about 4 to 154 $\mu g/m^3$. Since 80% of Virginia's adults are nonsmokers, this study has important positive implications for the economics of smoking bans as well as for nonsmokers' health, since such levels of irritation may drive a substantial fraction of nonsmokers to avoid these smoky venues, as Biener et al. (1999) found to be true in Massachusetts.

It is of interest to compare these data with those obtained in the Delaware Study (Repace, 2004). The Delaware venues included a casino, 6 bars, and a billiard parlor, and data ranged from a low of 44 $\mu g/m^3$ to a high of 686 $\mu g/m^3$, with a median value of 169 $\mu g/m^3$. However, after Delaware passed a smoke-free workplace law, the indoor median level dropped to 12 $\mu g/m^3$. Figure 9 shows the results of the Delaware survey. Can increased ventilation or air cleaning produce reductions comparable to a smoking ban? Repace (2005) has shown that the estimated air-change rate required for acceptable indoor air quality would be a tornado-like 121,500 air changes per hour. Ventilation technology cannot possibly achieve acceptable indoor air quality in the presence of smoking, leaving smoking bans as the only alternative.

Conclusions

Air quality was monitored in 11 smoking, 1 nonsmoking restaurant/bar venues in Virginia, in 19 outdoor locales, and 5 in-transit locations located in Richmond, Roanoke City, Dale City, Fredericksburg, and Virginia Beach. Air Quality was Code Green (Good) in the single nonsmoking venue, in all outdoor and in-transit locales (city streets, I-95, Powhite Toll Booth), and was Code Yellow (Moderate) in the Hampton Roads Tunnel on the upgrade. Secondhand smoke air pollution reached Significant Harm levels in one bar, Code Violet (Very Unhealthy) levels in a bingo hall, bowling alley, and 2 pubs, Code Red (Unhealthy) in a bar and 2 pubs, and Code Yellow (Moderate) in 3 restaurants. Smoker densities were half or less than for a bar at full occupancy, and were much lower in most restaurants. Averaged over all smoking venues, fine particle air pollution was 5 times higher than in the Hampton Roads Tunnel. Secondhand smoke (SHS) is causing unhealthy levels of air pollution in Virginia hospitality venues that are not being -- and cannot be -- controlled by ventilation, and are cause for grave concern for the respiratory health of hospitality workers and patrons. Virginia should enact a statewide smoke-free workplace law or permit local control for communities who value clean indoor air.

APPENDIX. Virginia State Air Quality Monitoring Results by Region

pm2005 – Netscape

http://www.deq.virginia.gov/airmon/pm2005.html

Commonwealth of Virginia | Web Policy | Governor of Virginia | Contact Us

DEQ VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Search Air Quality Go
Advanced search

pm2005Virginia DEQ: PM 2.5 Monitoring
Virginia DEQ Home > Air Quality Home > Air Monitoring Home > PM 2.5 Summary Data - 2005

email: Tom Jennings

Air Quality Home
Air Monitoring
Ozone/PM2.5
Air Forms
Air News
Compliance
Emissions
Permitting
Planning
Regulations
Power Plants
Public Notices
Staff
Links

VIRGINIA 2005
PM2.5 PARTICULATE MATTER SUMMARY BY REGION
METHOD CODE 118 - GRAVIMETRIC, R & P MODEL 2025 SEQUENTIAL
Micrograms Per Cubic Meter (ug/m3)

LOCATION	NO. OF OBSERVATIONS BY QUARTER				HIGHEST VALUE PER QUARTER				QUARTERLY ARITHMETIC MEAN			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
SOUTHWEST REGION												
BRISTOL Highlands View Elementary School	29	31	30		21.0	30.6	38.8		11.5	14.4	20.8	
VALLEY REGION												
LURAY Luray Caverns Airport	30	29	30		38.2	28.9	41.2		13.2	12.4	19.3	
WEST CENTRAL REGION												
ROANOKE Raleigh Court Library	30	30	29		21.2	31.1	39.2		11.4	14.6	22.7	
SALEM Market Street Fire Station	28	30	30		19.7	33.7	39.5		12.1	16.3	24.3	
LYNCHBURG Water Tank on Leesville Road	30	31	30		18.3	33.4	38.0		9.5	13.3	21.2	
PIEDMONT REGION												
CHESTERFIELD CO. Bensley Armory	30	29	30		21.1	28.5	38.7		12.7	13.1	19.1	
HENRICO CO. Math & Science Center	79	88	84		24.4	32.2	39.7		13.0	13.0	19.0	

VIRGINIA 2005
PM2.5 PARTICULATE MATTER SUMMARY BY REGION

LOCATION	NO. OF OBSERVATIONS BY QUARTER				HIGHEST VALUE PER QUARTER				QUARTERLY ARITHMETIC MEAN			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
PIEDMONT REGION (cont.)												
HENRICO CO. Piedmont Regional Office	29	25	26		21.3	28.0	35.5		12.0	13.5	19.2	
CHARLES CITY CO. Route #608	29	30	30		20.7	30.4	39.2		11.2	12.8	18.2	
TIDEWATER REGION												
HAMPTON Va. School for the Deaf & Blind	28	31	26		26.9	26.7	32.2		13.1	12.0	15.0	
NORFOLK NOAA Facility	27	28	30		26.0	26.3	34.6		14.0	12.9	16.2	
VIRGINIA BEACH Tidew ater Regional Office	77	84	64		28.7	34.7	38.8		12.2	11.7	15.6*	

*Quarter did not meet EPA's minimum requirements for data capture.

VIRGINIA 2005
PM2.5 PARTICULATE MATTER SUMMARY BY REGION

LOCATION	NO. OF OBSERVATIONS BY QUARTER				HIGHEST VALUE PER QUARTER				QUARTERLY ARITHMETIC MEAN			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
NORTHERN REGION												
LOUDOUN CO. Broad Run High School	28	30	27		25.0	25.8	40.7		13.7	12.0	21.7	
FAIRFAX CO. Lee District Park	90	80	84		30.2	27.8	41.8		12.8	12.3	18.8	
ARLINGTON CO. Aurora Hills	30	30	30		29.7	27.4	39.9		15.0	12.7	21.0	
FAIRFAX CO. McLean Governmental Center	23	27	26		29.9	28.9	39.3		15.1	13.5	19.2	
FAIRFAX CO. Annandale	30	31	28		28.5	26.8	37.2		13.8	12.8	20.1	

REFERENCES

Air Quality Index (AQI), EPA.gov; downloaded 28 July 2005: http://cfpub.epa.gov/airnow/index.cfm?action=static.aqi

American Society of Heating, Refrigerating, and Air-Conditioning Engineers) *Ventilation for Acceptable Indoor Air Quality, ASHRAE Standard 62-1989,* Atlanta, GA, 1989.

American Society of Heating, Refrigerating, and Air-Conditioning Engineers) *ANSI/ASHRAE Standard 62.1-2004 Ventilation for Acceptable Indoor Air Quality,* Atlanta, GA, 2004.

Biener, L., & Fitzgerald, G. (1999) Smoky bars and restaurants: who avoids them and why? *J Public Health Management and Practice*, 5, 74-78.

California Environmental Protection Agency (1997) Health Effects of Exposure to Environmental Tobacco Smoke, Final Report, Office of Environmental Health Hazard Assessment.

California Environmental Protection Agency (2005). Proposed Identification of Environmental Tobacco Smoke as a Toxic Air Contaminant. Scientific Review Panel Approved Report Part A and B, December 2005. California Air Resources Board, Sacramento, CA. http://www.arb.ca.gov/toxics/ets/dreport/dreport.htm

CDC (2005). Tobacco Information and Prevention Source (TIPS). Sustaining State Programs for Tobacco Control, Data Highlights 2004; Smoking Prevalence Among Adult Population Groups. < http://www.cdc.gov/tobacco/datahighlights/Page5.htm>, downloaded February 8, 2005.

Ellsworth, T. Air Protection Division, US EPA Region 3, Philadelphia, PA. ellsworth.todd@epa.gov. January 24, 2005, personal communication.

IARC (2004) IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. *Tobacco Smoke and. Involuntary Smoking, Volume 83,* International Agency for Research on Cancer, Lyon, France.

IARC Scientific Publications no.81, Environmental Carcinogens--Selected Methods of Analysis--Volume 9 Passive Smoking; I.K. O'Neill, K.D. Brunnemann, B. Dodet & D. Hoffmann, International Agency for Research on Cancer, World, Health Organization, United Nations Environment Programme, Lyon, France, (1987).

Junker MH, Danuser B, Monn C, and Koller T. Acute Sensory Responses of Nonsmokers at Very Low Environmental Tobacco Smoke Concentrations in Controlled Laboratory Settings. Environ Health Perspect 109:1045–1052 (2001).

MMWR (2004) — State–Specific Prevalences of Cigarette Smoking and Quitting Among Adults — United States, 2004 November 11, 2005 / Vol. 54 / No. 44. 1124-1127. TABLE 1. Prevalence of current cigarette smoking among adults,* by state/area and sex — Behavioral Risk Factor Surveillance System, 49 states,† District of Columbia, Puerto Rico, and the U.S. Virgin Islands, 2004.

National Cancer Institute. Respiratory health effects of passive smoking: lung cancer and other disorders; The report of the U.S. Environmental Protection Agency. National Cancer Institute Smoking and Tobacco Control Monograph 4, NIH Publication # 93-3605, National Institutes of Health, Bethesda, MD., August 1993.

National Cancer Institute. *Smoking and Tobacco Control Monograph 10. Health Effects of Exposure to Environmental Tobacco Smoke, Final Report.* The Report of the California Environmental Protection Agency (1999).

National Research Council (1986). *Environmental tobacco smoke -- measuring* *exposures and assessing health effects.* National Academy Press, Washington, DC.

National Toxicology Program. 9th Report on Carcinogens 2000. U.S. Dept. of Health & Human Services, National Institute of Environmental Health Sciences, Research Triangle Park, NC.

NIOSH Current Intelligence Bulletin #54. *Environmental Tobacco Smoke in the Workplace, Lung Cancer and Other Health Effects.* U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health, Cincinnati, OH June 1991.

OSHA. U.S. Dept. of Labor, Occupational Safety & Health Administration. 29 CFR Parts 1910, 1915, 1926, and 1928 Indoor air quality, proposed rule Fed Reg 59 # 65, Tues April 5, 1994, 15968-16039.

Ott, W., Switzer, P., and Robinson, J. (1996) Particle concentrations inside a tavern before and after prohibition of smoking: evaluating the performance of an indoor air quality model*, Journal of the Air & Waste Management Association,* **46**: 1120-1134.

Repace J, Hughes E, and Benowitz N. Exposure to Secondhand Smoke Air Pollution Assessed from Bar Patrons' Urine Cotinine. Nicotine and Tobacco Research (in press).

Repace JL. Controlling Tobacco Smoke Pollution. *Technical Feature*, ASHRAE IAQ Applications: 6, #3, 11-15 (2005).

Repace JL. Human Exposure to Secondhand Smoke. W.R. Ott, L.A. Wallace, & A.M. Steinemann (Eds.), In *Human Exposure Analysis,* (CRC Press, in press)

Repace JL. Indoor concentrations of environmental tobacco smoke: field surveys. Ch. 10, *IARC Scientific Publications no. 81, Environmental Carcinogens--Selected Methods of Analysis--Volume 9 Passive Smoking;* I.K. O'Neill, K.D. Brunnemann, B. Dodet & D. Hoffman, International Agency for Research on Cancer, World, Health Organization, United Nations Environment Programme, Lyon, France, (1987).
Samet JM, Dominici F, Curriero FC, Coursac I, Zeger SL. Fine Particulate Air Pollution and Mortality in 20 U.S. Cities, 1987-1994. N Engl J Med 2000;343:1742-9.

Repace JL. Respirable Particles and Carcinogens in the Air of Delaware Hospitality Venues Before and After a Smoking Ban. Journal of Occupational and Environmental Medicine, 46:887-905 (2004).

Surgeon General. *The Health Consequences of Involuntary Smoking, A Report of the Surgeon General.* U.S. Dept. of Health and Human Services, Washington, DC (1986).

Travers, M.J., Cummings, K.M., Hyland, A., Repace, J., Babb, S., Pechacek, T, & Caraballo R. (2004). Indoor Air Quality in Hospitality Venues Before and After Implementation of a Clean Indoor Air Law — Western New York, 2003. *MMWR* Vol. 53 / No. 44, 1038-104, November 12.

U.S. EPA, Health Effects of Passive Smoking: Assessment of Lung Cancer in Adults, and Respiratory Disorders in Children. EPA/600/6-90/006F, December (1992)

U.S. EPA, Office of Air and Radiation. EPA's Revised Particulate Matter Standards. Fact Sheet, Office of Air Quality Planning & Standards, July 17, 1997.

United States Environmental Protection Agency. GUIDELINE FOR REPORTING OF DAILY AIR QUALITY - AIR QUALITY INDEX (AQI) Office of Air Quality Planning and Standards July 1999 Research Triangle Park, NC 27711; EPA-454/R-99-010.

Table 3. December 2005 Virginia Indoor/Outdoor Air Quality Survey Results

Venue, Date, Locale	Area (ft^2)	Ceiling Height (ft)	Volume (m^3)	Ave. # Persons Present[a]	Ave. # Persons per 1000 ft^2	Ave. # Burning Cigarettes[a]	Averaging Time, min	Estimated Smoker Prevalence, %	Ave. Venue RSP, $\mu g/m^3$	Ave. Outdoor Level, $\mu g/m^3$	AQI** Code for Venue	D_s, Active Smoker Density	C_v, Est. Air exchange rate, (h^{-1})
Bingo Hall Richmond 12/02	2,688	9.5	723	48	20	7	42	43.8	223	7	Violet	0.97	2.9
Pub A Richmond 12/02	1,890	9.0	482	129	68	4.33	58	10	97	8	Red	0.90	6.6
Pub B 12/03 Virginia Beach	1,474	8.0	334	56	38	3	62	16%	83	11	Red	0.90	8.1
Bowling 12/03 Virginia Beach	16,913	11.0	5268	145	8.6	9.5	32	19.7	221	11.5	Violet	0.18	0.55
Pub C Roanoke 12/07	3,700	13.33	1388	26	7.0	1.5	33	17.3	181	4.5	Violet	0.11	0.41
NS† Restaurant Roanoke 12/07	1,170	8.25	273	17	15	0	49	0	4.4	3.3	Green	0	-
Bar A Roanoke 12/07	2,310	10.92	714	42.5	18	7.33	46	51.8	680	3.5	--	1.03	0.99
Restaurant A Richmond 12/10	3,306	14.0	1311	153	46	2	81	3.9	40	14	Yellow	0.15	3.75
Restaurant B Richmond 12/10	2,527	9.83	703	23.7	9.4	1.33	49	16.8	38	14	Yellow	0.19	5.1
Restaurant C Richmond 12/15	1,156	10.13	316	10.5	9	2	54	57%	21	5.3	Yellow	0.60	24.8*
Pub D Richmond 12/15	840	13.75	327	18	21	2.5	39	44	241	5.3	Violet	0.76	2.1
Bar B 12/15 Fredericksburg	10,104	9.0	2135	78	7.7	7	40	26.9	138	5.3	Red	0.33	1.6
All Smoking	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**27.9**	**178**	**8.1**	-	**-**	**-**
All Outdoors		∞					245			7.3	Green	0	
Powhite Pkwy Extn. Toll Booth		∞					40			5.7	Green	0	
I-95 Roadside Dale City		∞					101			6.3	Green	0	
Hampton Roads Tunnel		13.83					54			37	Yellow	0	

*Drafty, chilly inside, cold night outside. Days of Week: Dec. 2, Friday; Dec. 3, Sat.; Dec. 7, Weds.; Dec. 10, Sat.; Dec. 15, Thurs.

**See Table 2 for meaning of color descriptors. †(NS = nonsmoking).

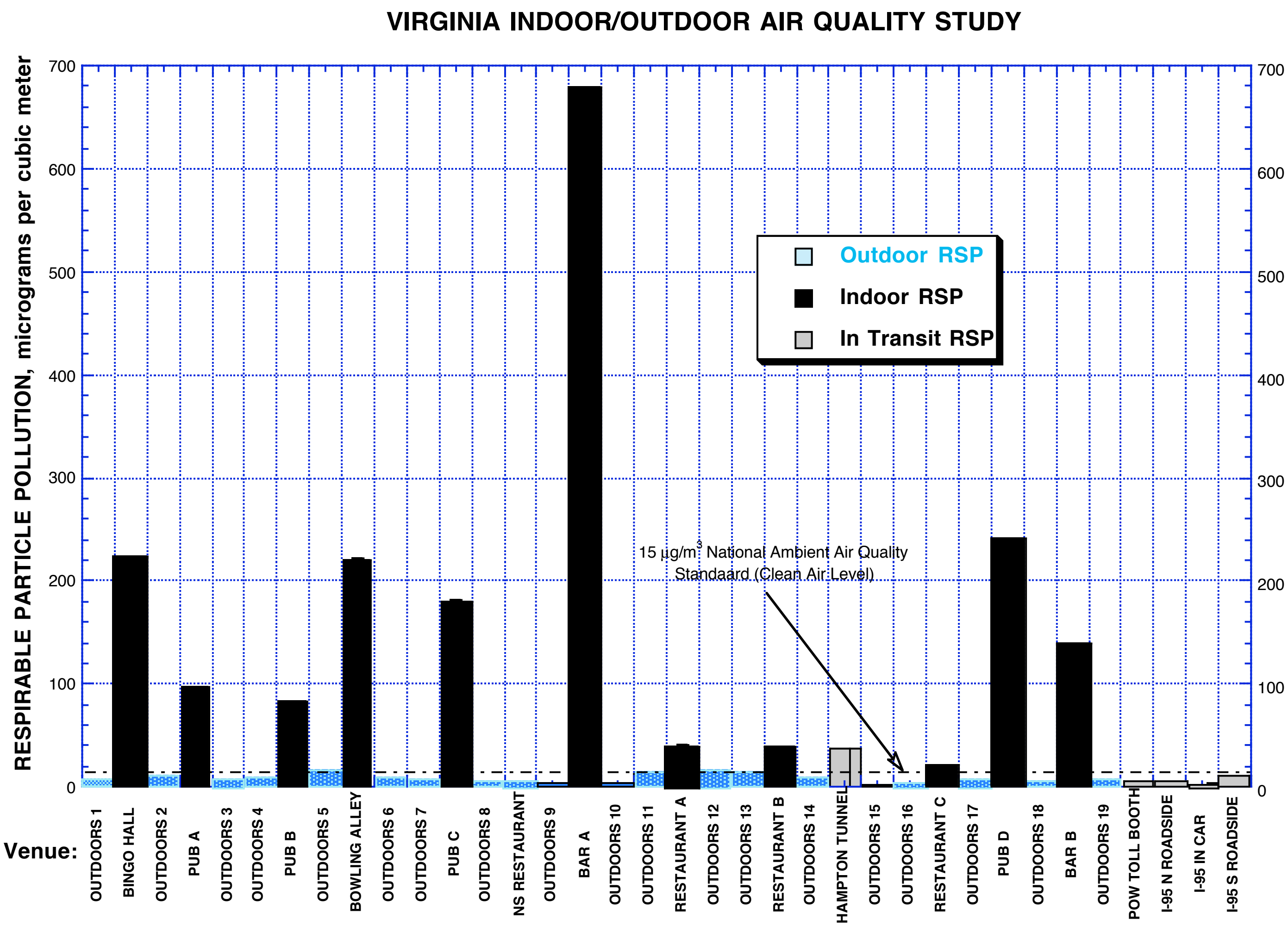


Figure 5. PM2.5 Levels measured by the SidePak monitor for each of 12 indoor venues, 19 outdoor venues, and 5 in-transit venues.

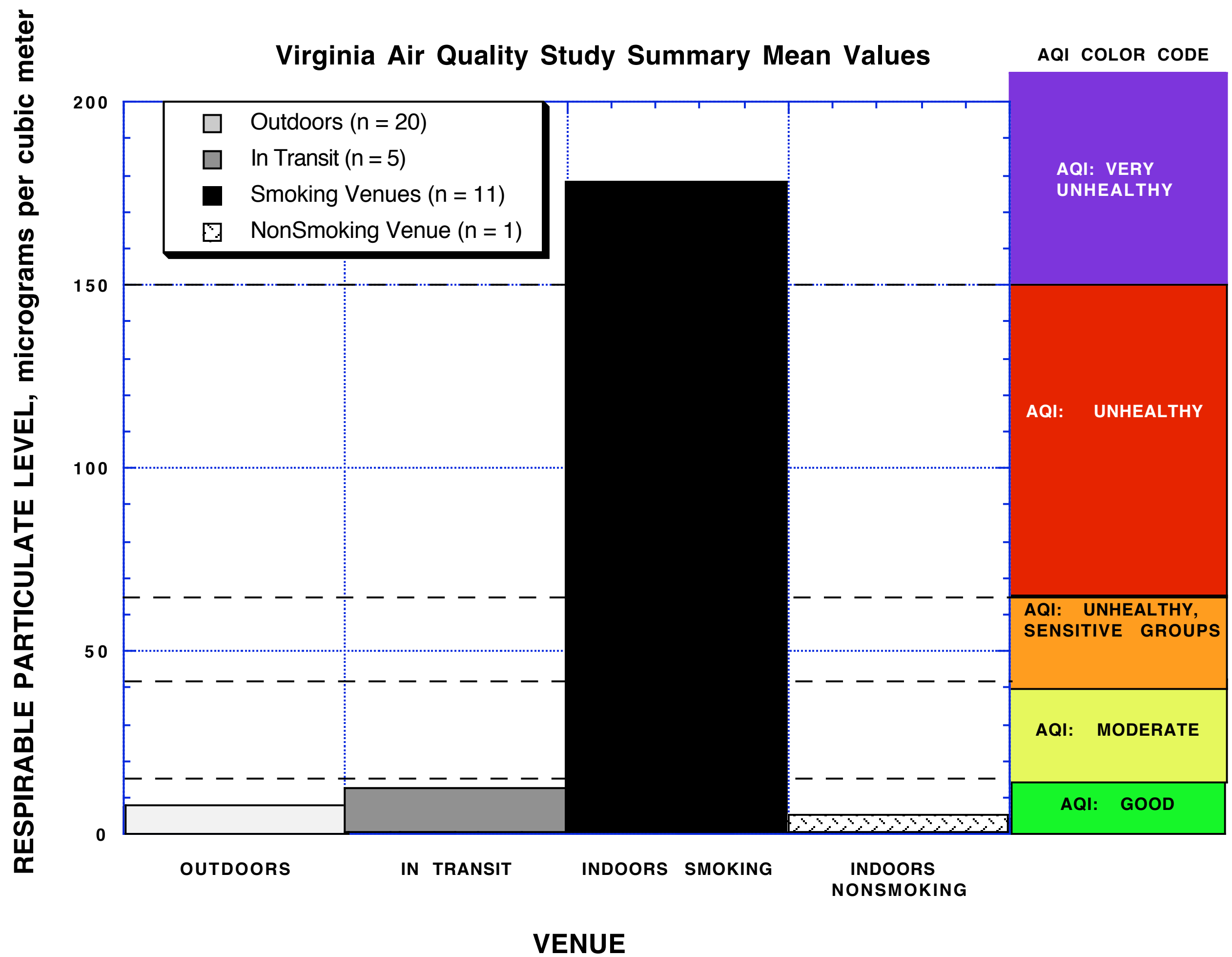


Figure 6. Summary Mean $PM_{2.5}$ values for 4 categories: Indoor smoking venues vs. indoor nonsmoking, outdoors in transit, and outdoors. The color-coded Federal Air Quality Index is shown for purposes of placing the magnitude of the measured levels in perspective.

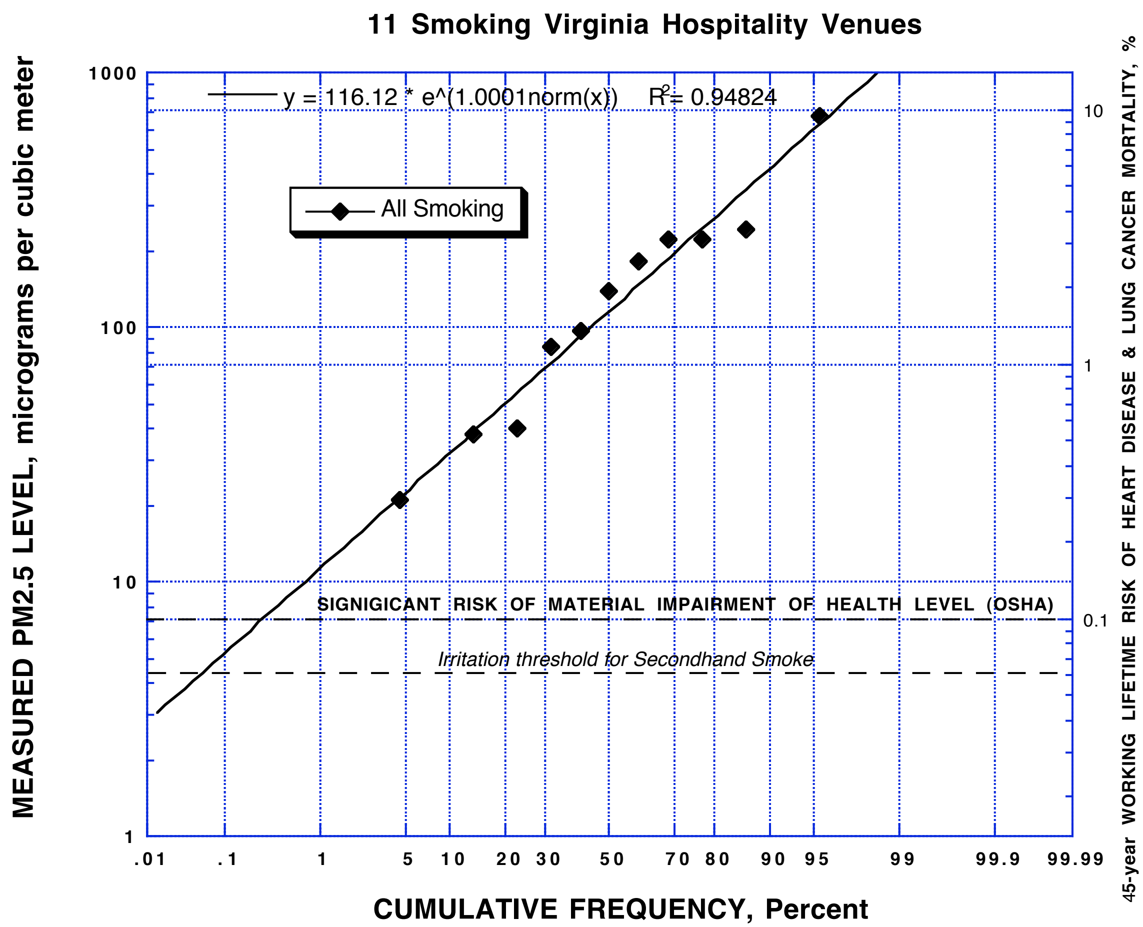


Figure 7. Log-probability plot of RSP levels and estimated mortality risk measured in 11 smoking Virginia hospitality venues. OSHA's Significant Risk Level of 1/1000 is exceeded in all 11 venues. All Venues also exceeded the nonsmokers' irritation level by factors of from 4 to 154, when non-SHS background RSP was subtracted.

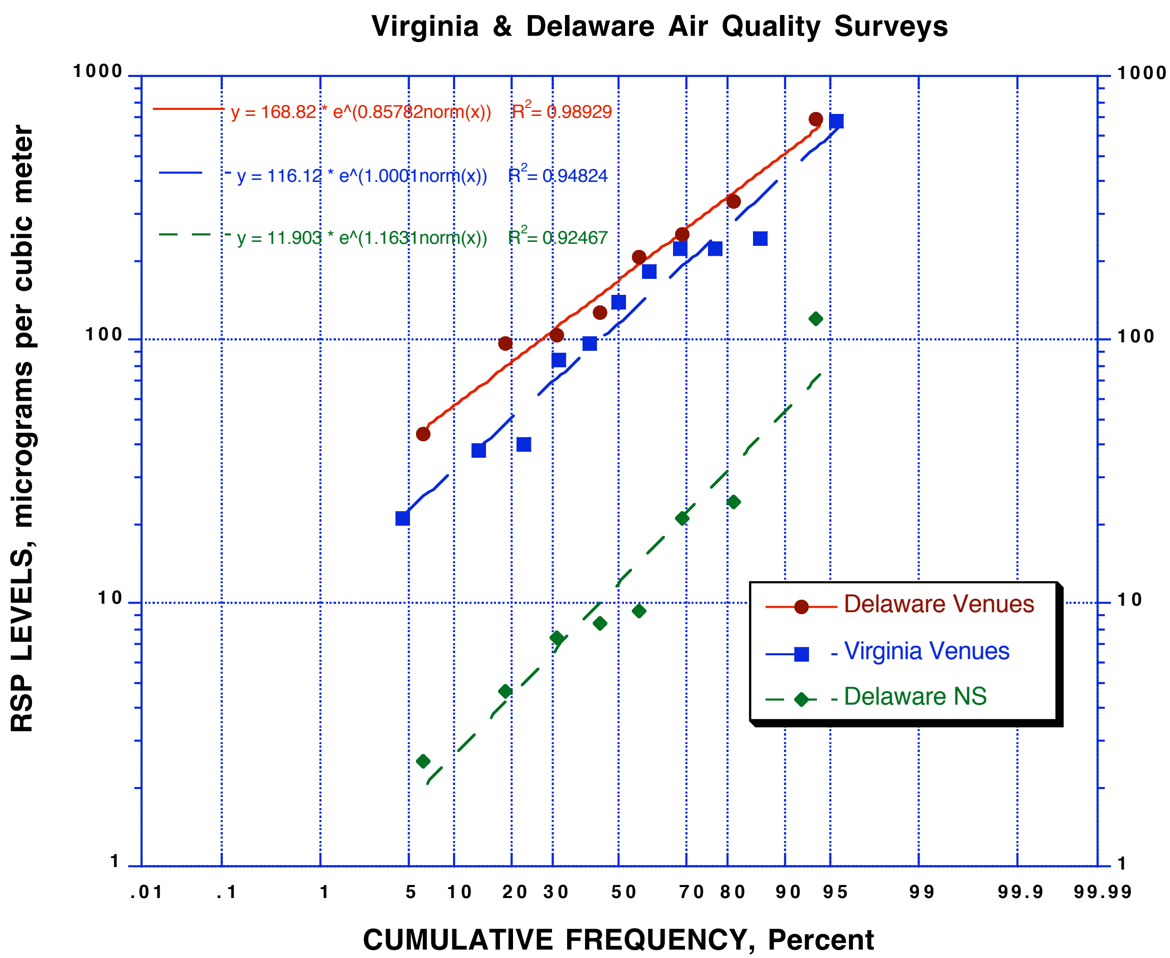


Figure 8. Virginia Air Quality Survey (Virginia Venues) vs. the Delaware Air Quality Survey, pre- (Delaware Venues) and post (Delaware NS) a Statewide smoking ban (Repace, 2004). The Delaware study included a casino, 6 bars, and a billiard hall.

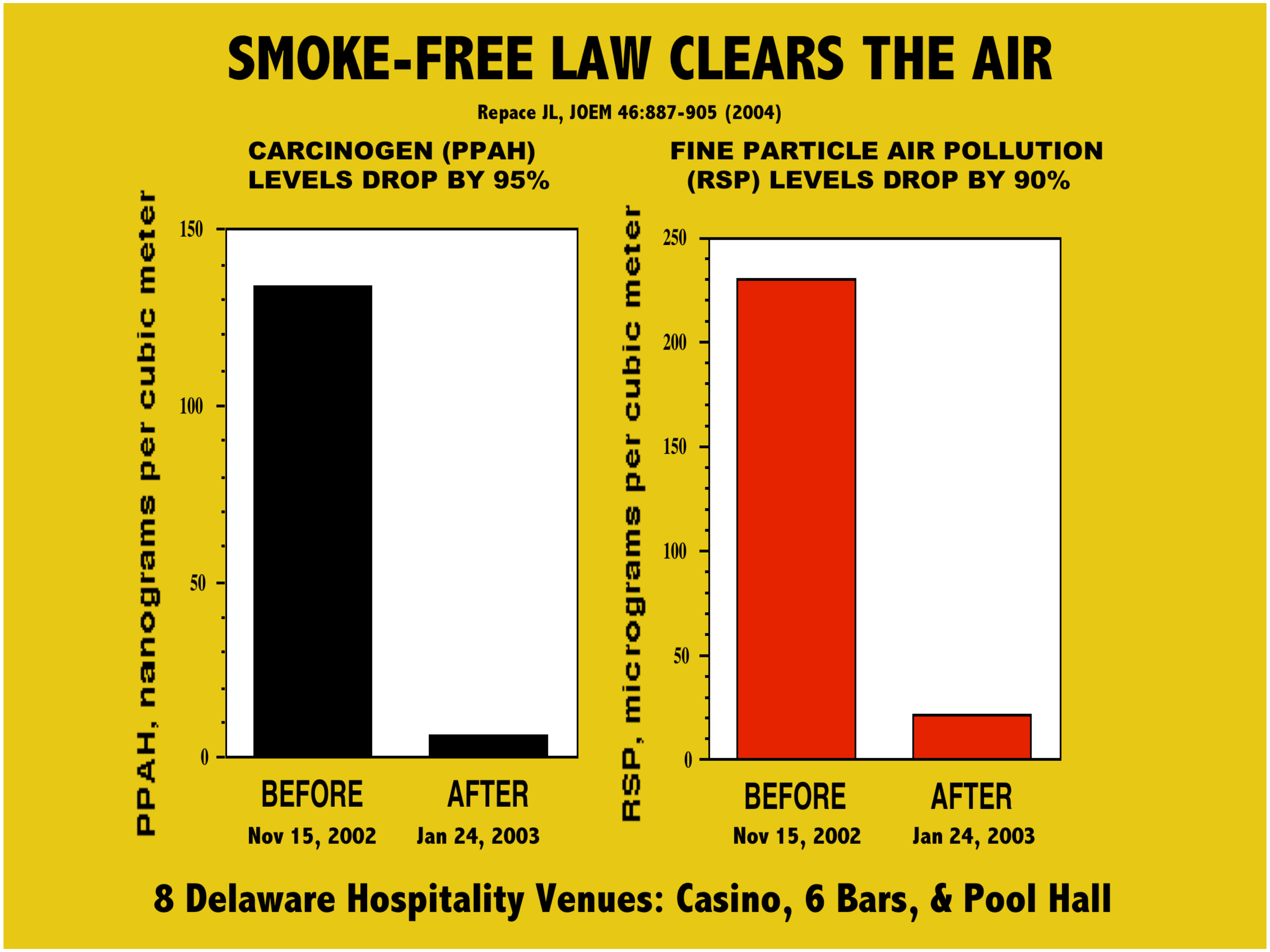


Figure 9. The Effect of Delaware's Clean Indoor Air Law on Hospitality Industry Secondhand Smoke Pollution