Smoke, Dust & Haze

EPA NW Research Center for Particulate Air Pollution and Health Newsletter

Winter 2003

Seattle skyline at increasing levels of particulate matter.

Welcome to another issue of the EPA NW PM Center newsletter. One of the most important goals of our Center, and of research universities in general, is training students. In this issue we highlight student research that has been or is being supported by the Center. We are very proud of our students' progress and trust you will read about their research with much interest.

—Jane Q Koenig, PhD

PNWIS 2002 Annual Awards Presentation

Each year, the Pacific Northwest International Section (PNWIS) of the Air & Waste Management Association (A&WMA) awards cash prizes to students who present papers at our annual conference. Funding comes from the PNWIS Education and Public Outreach Committee budget and the Fred Gray Scholarship Fund.

The students are evaluated on technical content, visual aids, and presentation skills. Judging is informal. We use a form that conference delegates and the PNWIS Board of Directors complete at sessions where students are presenting papers. They present the forms or their verbal recommendations to the Awards Committee Chair, and we award the prizes based on the majority of votes.

PNWIS is a catalyst for environmental leadership by providing a neutral forum for discussion, education, and networking on technical issues relating to environmental management in the US Pacific Northwest and Western Canada.

The PNWIS was formed in 1961 to promote the interchange of technical information regarding the control of air pollution and was chartered by A&WMA on in 1962. Over 900 individuals in Alaska, British Columbia, Idaho, Montana, Oregon, Washington and the Yukon are members. Approximately 800 other individuals are associated with local chapters. Members are technical and professional people from industry, academia, government, manufacturers, consulting and testing firms, and the public sector.

You will find more information about PNWIS at our web site *www.pnwis.org*.

—Angela Hansen
PNWIS Awards Committee Chair

2002 Award Recipients

Abby Coleman

First Place
Trevor Taylor, Montana Tech

Second Place
Jorge Jimenez, Washington State University *(top)*

Bethany Katz

Third Place
Ryan Allen, University of Washington *(bottom)*

Agricultural field burning in the Palouse

Jorge Jimenez

Department of Civil Engineering, Laboratory for Atmospheric Research, Washington State University, Pullman, Washington

Abby Coleman

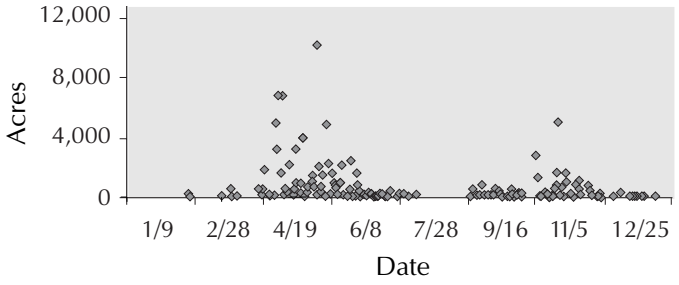

Figure 1. Burning distribution, year 2001

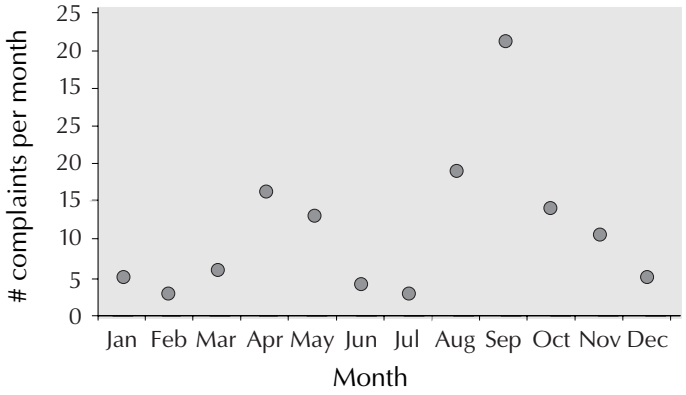

Figure 2. Total complaints, year 2001

Jimenez received a BS in Industrial Civil Engineering at the University of Concepcion in Chile in 1998 and an MS in Environmental Science at Washington State University in 2002. His undergraduate thesis focused on sustainable methods and reduction of environmental impacts of marine resource farming in Southern Chile. This experience increased his interest in environmental issues. He was awarded scholarship support to pursue a master's degree in environmental science outside Chile. During the application process, he attended a conference in Chile about environmental issues organized by WSU and local universities. There, he met WSU faculty members, and subsequently, he decided to pursue his graduate degrees in Pullman.

In spring and fall each year, cereal crop farmers in the Palouse region of Washington state prepare fields for seeding through field burning. Fire is one of the practices used to control pests, decreasing the need for pesticide applications. Field burning, regulated in Washington by the state Department of Ecology (DOE), is allowed when ventilation conditions are likely to disperse smoke away from urban areas. Despite efforts to manage agricultural burning, DOE receives numerous smoke-related complaints during burn seasons.

The objective of this study was to characterize the extent of air quality impacts, specifically in the eastern Washington community of Pullman, due to regional agricultural field burning. Burn seasons of 2000 and 2001 were selected for analysis. By examining air quality and meteorological data, burn calls, permits, reports, and citizen complaints, we developed backward trajectories for selected smoke episodes.

Eight smoke events were analyzed. Results show that in four cases agricultural field burning contributed to observed air pollution. From 2000 to 2001 the number of acres burned in eastern Washington decreased. In 2000, numerous episodes of smoke intrusion observed in Pullman were related to wildfires in the area. Air quality impacts, as measured by both particulate measurements and by citizen complaints, were greater in the fall than in the spring for both years. Although more burn days were called in spring (burn calls prohibit burning) compared to fall, more acres were burned in spring. Agricultural field burning in Idaho affected air quality in Pullman on several occasions.

A new molecular tracer for wood smoke

Bethany S. Katz

Department of Environmental and Occupational Health Sciences, Dave Kalman Laboratory, University of Washington

Heather Long

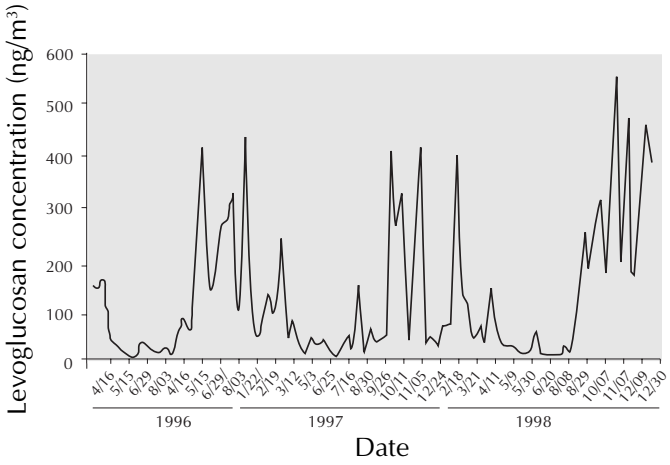

Figure 1. Measured levoglucosan concentrations at Beacon HIII 1996–1999

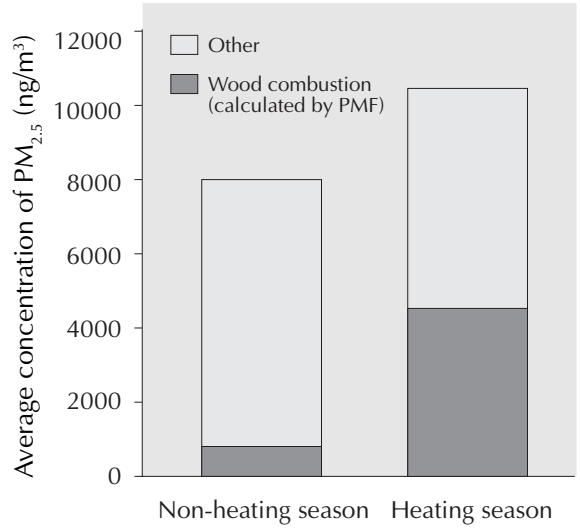

Figure 2. Average contribution to $PM_{2.5}$ by season

THIS STUDY WILL PROVIDE AN IMPROVED ESTIMATE for the proportion of fine particulate matter resulting from wood combustion. Since a fine particulate matter standard was added to the National Ambient Air Quality Standard, we need better ways to determine sources of this size fraction of particulate matter, which can guide regulatory strategies.

Previous source apportionment models from the Seattle area vary significantly in the assignment of the relative importance of diesel and wood smoke to fine particulate matter. This discrepancy can have a profound impact on risk assessments, epidemiologic studies, and control strategies, all of which rely on an accurate assessment of sources and composition of particulate matter.

Recently emerging analytical techniques allow for quantification of polar organic molecules that can be used as wood smoke tracers, leading to more accurate quantification of the concentration of ambient fine particulate matter from wood smoke. The quantification of levoglucosan, one of these organic molecules, in Seattle particulate matter provides a recalculation of the proportion of ambient particulate matter derived from wood smoke.

A subset (N=93) of the samples collected at the Beacon Hill air monitoring site from 1996–1999 were extracted using methods previously developed by Simpson et. al for the quantification of methoxyphenols. These samples were analyzed for levoglucosan using GC/MS. Levoglucosan was detected in all samples (mean, minimum and maximum concentrations = 119; 5; 557 ng/m³). The relative contributions of wood-derived $PM_{2.5}$ to overall $PM_{2.5}$ will be calculated using the organic tracer method, UNMIX, and Positive Matrix Factorization. The figures show preliminary results.

Originally from New Haven, Connecticut, Katz's undergraduate degree is a ScB in Geology from Brown University (class of 1997). Her faculty advisors are Dave Kalman, Chris Simpson, and Tim Larson.

The use of real-time light scatter data

Ryan Allen

Department of Environmental and Occupational Health Sciences, Sally Liu Laboratory, University of Washington

Bethany Katz

Allen earned his BS in Physics from Denison University (Granville, OH) in 1998 and his MS in Environmental Engineering from the University of Washington in 2000.

THE MOST CHALLENGING TASK in estimating personal exposure to ambient-generated particulate matter (PM) is to identify particles that were generated indoors and outdoors. The distinctions are especially important during seasons when people open their windows. We have developed a model that can identify particulates generated by indoor activities such as cooking and vacuuming.

One of the most important parameters for making such a separation is the particle infiltration efficiency (F_{inf}), a unitless quantity defined as the equilibrium fraction of ambient PM that penetrates indoors and remains suspended. F_{inf} is a function of particle penetration efficiency, which is the fraction of ambient PM that is not removed from ambient air during its entry into the indoor volume, the particle removal rate due to diffusion or sedimentation, and the air exchange rate.

The associations between short-term particulate matter (PM) excursions and health effects invite further characterization of short-term PM exposures —those at averaging times less than 24-hours. Separating indoor PM into indoor- and outdoor-generated components will greatly enhance our knowledge of the outdoor contribution to total indoor and personal PM exposures.

This study examines continuous light scattering data at 55 residences in Seattle, Washington. A newly developed recursive model was used to model outdoor-originated PM entering indoor

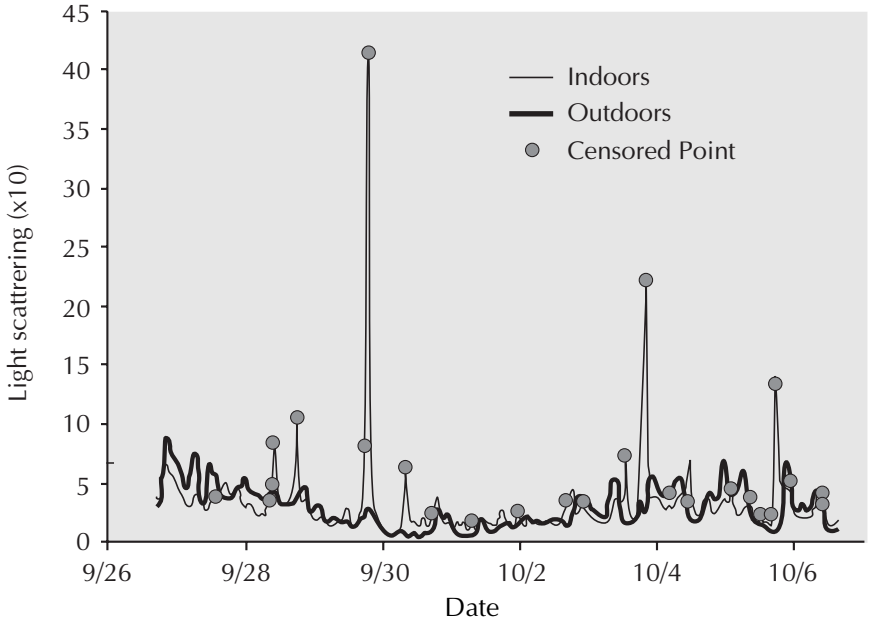

Figure 1. An example of a censored indoor time series

environments. Non-linear regression was used to predict particle penetration, air exchange rate, particle decay rate, and particle infiltration for each residence. The F_{inf} estimates agree well with those estimated from the sulfur-tracer method.

This study was a subset of a larger exposure assessment panel study conducted between November 1999 and May 2001. Subjects were recruited throughout the metropolitan Seattle area, including 56 elderly subjects and 17 pediatric asthmatics. The elderly subjects included healthy subjects and persons with chronic obstructive pulmonary disease (COPD) and coronary heart disease (CHD). All subjects were nonsmokers living with nonsmokers.

Particle mass and light scattering were monitored during 24 ten-day monitoring sessions. Light scattering was monitored using the real-time Radiance nephelometers, both inside and immediately outside the subjects' residences.

Among our study residences, indoor-generated particles accounted for an average of 21 ± 19% of the indoor PM concentration, with a range of 0 to 79% at individual residences. The factors affecting F_{inf} were season, the number of days with at least one open window, and the use of an indoor air cleaner. Frying, baking, unidentified cooking, vacuuming, and the presence of field technicians in the residence were all significant indoor sources of light scattering.

Identifying indoor sources is a crucial prerequisite to running the recursive model. Our censoring method for identifying indoor sources includes larger indoor peaks that have no corresponding large outdoor increase and low-level indoor sources with a very small increase (2.5×10^{-6} m^{-1} or approximately 1 μg/m^3) in indoor light scattering without a corresponding outdoor increase. Our censoring method, however, does not identify constant indoor sources, such as those that may be generated from constantly operating furnaces. The intercept in the GEE model (Table) was 0.59 ± 0.05, indicating that some indoor sources were unaccounted for. While this may be a potential problem, previously published studies indicate that PM levels resulting from indoor sources are generally "spikes" displaying a rapid increase and subsequent decay. Thus, constant indoor sources may account for a very small percentage of the total indoor contribution.

Table 1: Distribution of parameters estimated from non-linear regression of the recursive model on open- and closed-window days.

Parameter	Windows	Mean	Min.	10%	25%	50%	75%	90%	Max.
F_{inf}	Open[a]	0.69*	0.18	0.43	0.52	0.70	0.90	1.00	1.00
	Closed[b]	0.59*	0.07	0.34	0.47	0.58	0.72	0.88	1.00
	All Days	0.66	0.07	0.36	0.51	0.64	0.82	1.00	1.00
P	Open[a]	0.93	0.31	0.71	1.00	1.00	1.00	1.00	1.00
	Closed[b]	0.88	0.11	0.57	0.77	1.00	1.00	1.00	1.00
	All Days	0.92	0.11	0.59	1.00	1.00	1.00	1.00	1.00
a (hr^{-1})	Open[a]	0.56	0.05	0.19	0.28	0.38	0.64	0.99	4.62
	Closed[b]	0.41	0.04	0.14	0.24	0.33	0.57	0.76	1.18
	All Days	0.54	0.10	0.20	0.29	0.38	0.69	0.96	4.46
k (hr^{-1})	Open[a]	0.16	0.00	0.00	0.06	0.12	0.24	0.36	0.55
	Closed[b]	0.18	0.00	0.00	0.10	0.16	0.24	0.34	0.58
	All Days	0.18	0.00	0.00	0.09	0.14	0.23	0.45	0.74

[a] Based on 43 sites (44 sites had at least one open-window day, but site 1 did not converge due to the smaller datasets after separating by window status)

[b] Based on 34 sites (36 sites had at least one closed-window day, but 2 sites did not converge).

* 2-sample t-test, $p<0.05$

Looking at the cardiopulmonary effects of a normal urban dose of nitrogen dioxide on people with heart or lung disease

Katia Harb

Department of Environmental and Occupational Health Sciences, Jane Koenig Laboratory, University of Washington

Elie Karim

Harb received a BS in Environmental Health from UW in 2000. Her thesis committee members are Jane Koenig, Joel Kaufman, Therese Mar, and Chris Simpson.

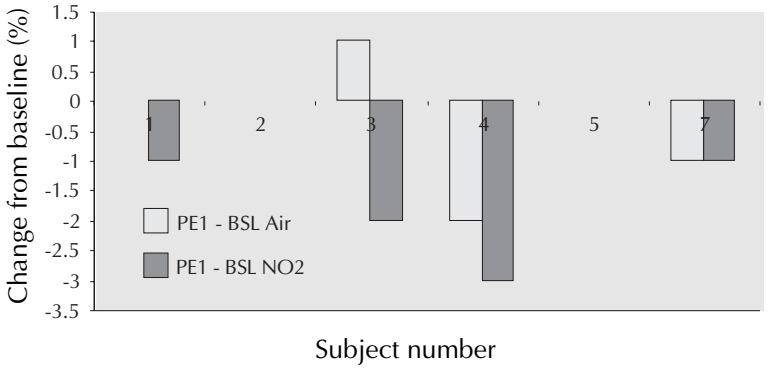

Figure 1. Percent change in blood oxygen saturation after 30-minute exposures

Nitrogen dioxide (NO_2) gas is emitted by motor vehicles and coal-fired power plants. It can damage the lung through oxidant injury; its biological effects on the cardiac system remain largely unknown. Previous studies have linked short-term exposures to changes in airway responsiveness and lung function among people with respiratory illnesses.

The purpose of this study was to determine if exposure to 300 parts per billion (ppb) NO_2 (the concentration that may be experienced at a bus stop), could cause short-term, sub-clinical cardiovascular and pulmonary effects in patients with chronic obstructive pulmonary disease (COPD) or asthma. This double-blind crossover study exposed six subjects, 50 or older, to filtered air and 300 ppb NO_2 for 30 minutes while resting.

Pulmonary system measurements included arterial oxygen saturation, exhaled nitric oxide and carbon monoxide, 8-isoprostane levels in exhaled breath condensate, and lung function. Cardiovascular measurements included blood pressure and heart rate. These measurements and symptom ratings were collected before exposure, 30 minutes after exposure, and 18 hours after exposure. Paired t-tests and bootstrap analyses were used to compare differences in post-exposure measurements with baseline measurements for both sessions.

The results of this study showed no significant changes in cardiopulmonary function attributable to nitrogen dioxide exposure; however some patterns were observed. Arterial oxygen saturation decreased in three of the six subjects after exposure to NO_2. This was not observed after exposure to filtered air.

2002–03 news, events & publications

Events & Visitors

September
Seminar: Edward Gill, MD, UW Division of Cardiology, *Particulate Matter Effects on Endothelial Function*

Philip K. Hopke, PhD, Clarkson University, *Advanced Factor Analysis for Receptor Modeling*

October
Michael Kleinman, MD, University of California Irvine, *Freeway PM and cardiopulmonary responses in rats*

Seminar: Michael Madden, PhD, US EPA, Research Triangle Park, North Carolina, *Diesel exhaust particulate health effects: Results from in vitro and in vivo studies*

External Science Advisory Committee Meeting, October 29 and 30

November
Pacific Northwest International Section of the Air & Waste Management Association 2002 Annual Conference, November 5-8, *Environmental Solutions in a Changing World*

December
Sambandam Sankar, PhD,
Environmental Health Engineering Cell at Sri Ramachandra Medical College & Research Institute, TamilNadu, India, *Daily Average Exposures to Respirable Particulate Matter from Combustion of Biomass Fuels in Rural Households of Southern India, EHP Volume 110 Number 11 November 2002*

January
Seminar: Tim Larson, PhD, UW Department of Civil and Environmental Engineering, *Sources of Indoor and Outdoor* $PM_{2.5}$

Seminar: Candis Claiborn, PhD, WSU Department of Civil and Environmental Engineering, *Characterization of Agricultural Burning Smoke: Composition, Community Exposure, and Health Effects*

February
Seminar: William Lambert, PhD, Oregon Health & Sciences University Center for Research on Occupational and Environmental Toxicology, *Dialkyl phosphate levels in urine samples from children of migrant farmworkers*

Seminar: Rey de Castro, SD, Harvard School of Public Health Department of Environmental Science and Engineering, *Monitoring Human Gene Expression Induced by Urban* $PM_{2.5}$ *Utilizing cDNA Microarrays*

Presentations

September
Lianne Sheppard at the Environmental Lung Center External Advisory meeting in Denver, Colorado

November
Tom Lumley and Lianne Sheppard at the EPA workshop on GAM-Related Statistical Issues, Research Triangle Park

November
Lianne Sheppard at the NERAM Colloquium: *Interpreting Epidemiological Studies of Acute & Long Term Exposure to Particulate Matter for Policy Development* in Baltimore, Maryland

January
Joel Kaufman delivered the Alice Hamilton Lecture at University of California San Francisco Medical Grand Rounds *Emerging Occupational and Environmental Diseases*

January
Carol Trenga, Allies Against Asthma Community Health Meeting in Burien, *Nutrition and Asthma*

February
Carol Trenga, Linus Pauling Institute, Oregon State University, Corvallis, Oregon, *Respiratory and Cardiovascular Effects of Particulate Air Pollution: Results from Human Studies*

February
Carol Trenga, Allies Against Asthma Community Health Meeting in Renton, *Nutrition and Asthma*

Publications

Claiborn C, Larson T, and Sheppard L. Testing the metals hypothesis in Spokane. *Environmental Health Perspectives Supplement — Monograph on Environmental Air Toxics: Role in Asthma Occurrence?* (supplement 4):547-552, 2002.

Lumley T and Sheppard L. Time series analyses of air pollution and health: Straining at gnats while swallowing camels? *Epidemiology* 14:13-14, 2003.

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