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Health Impacts of Power Plants: How to Assess Them

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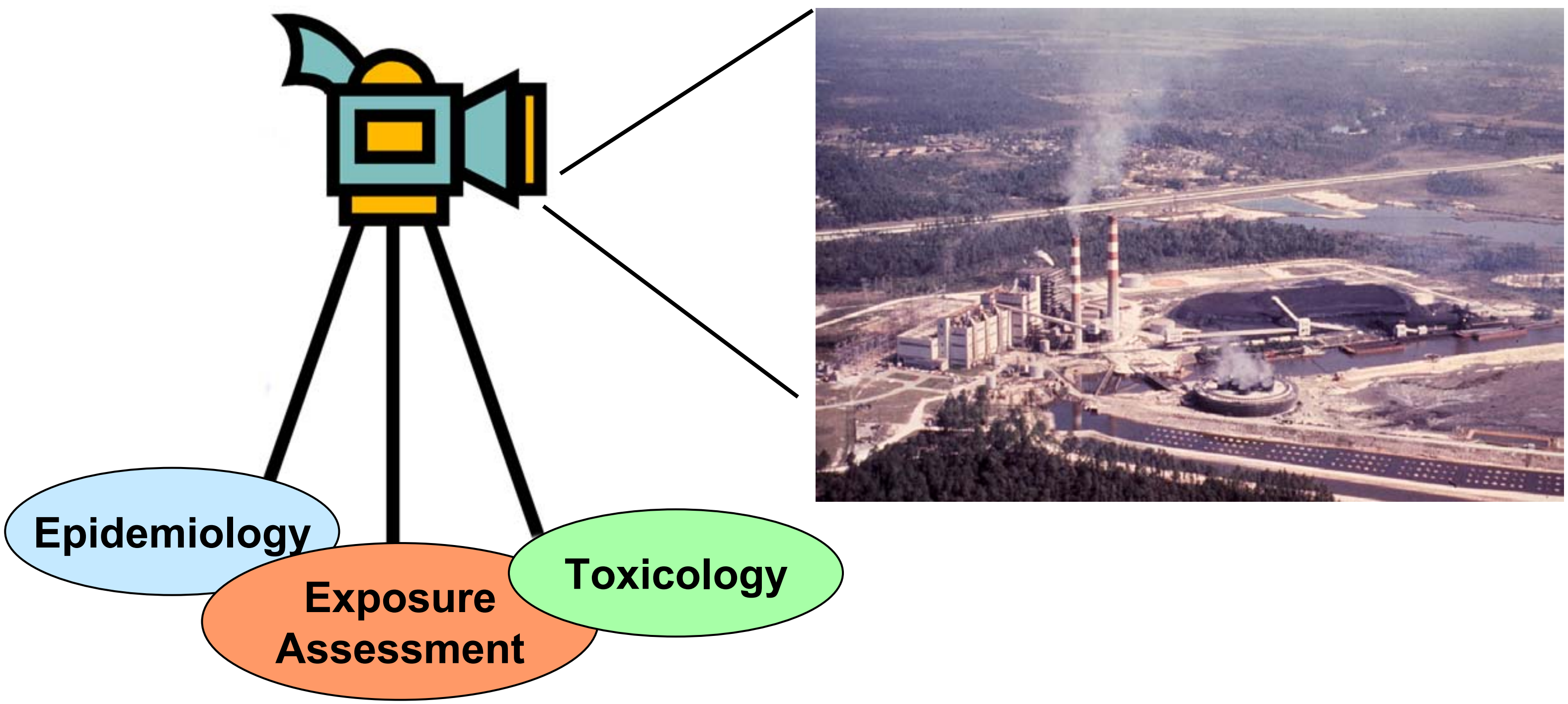
Air Pollution Health & Power Plants

How Do We Assess Effects?



Power Plant Emissions

SO_2, NO_x

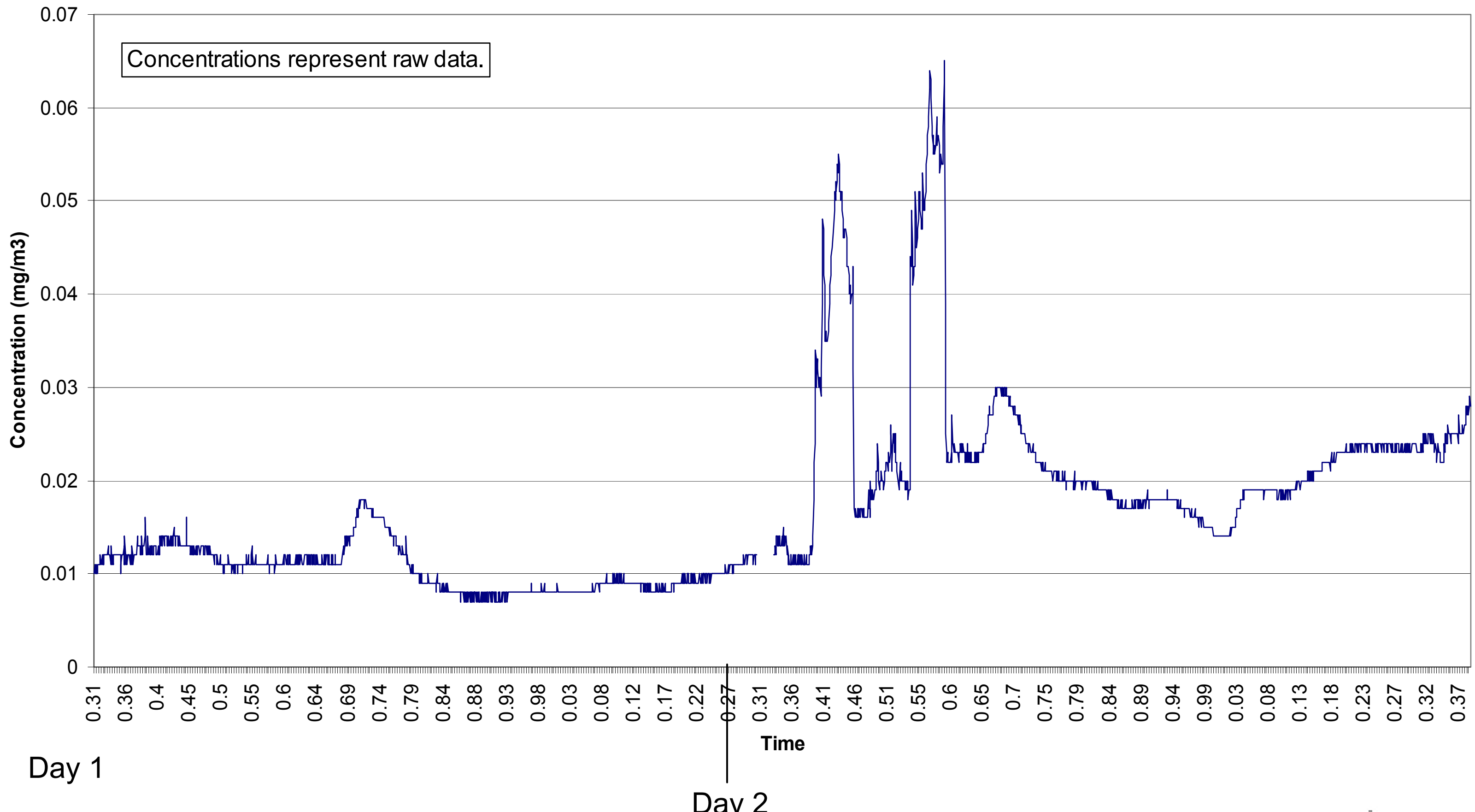
↓

sulfates, nitrates, ozone

Exposure

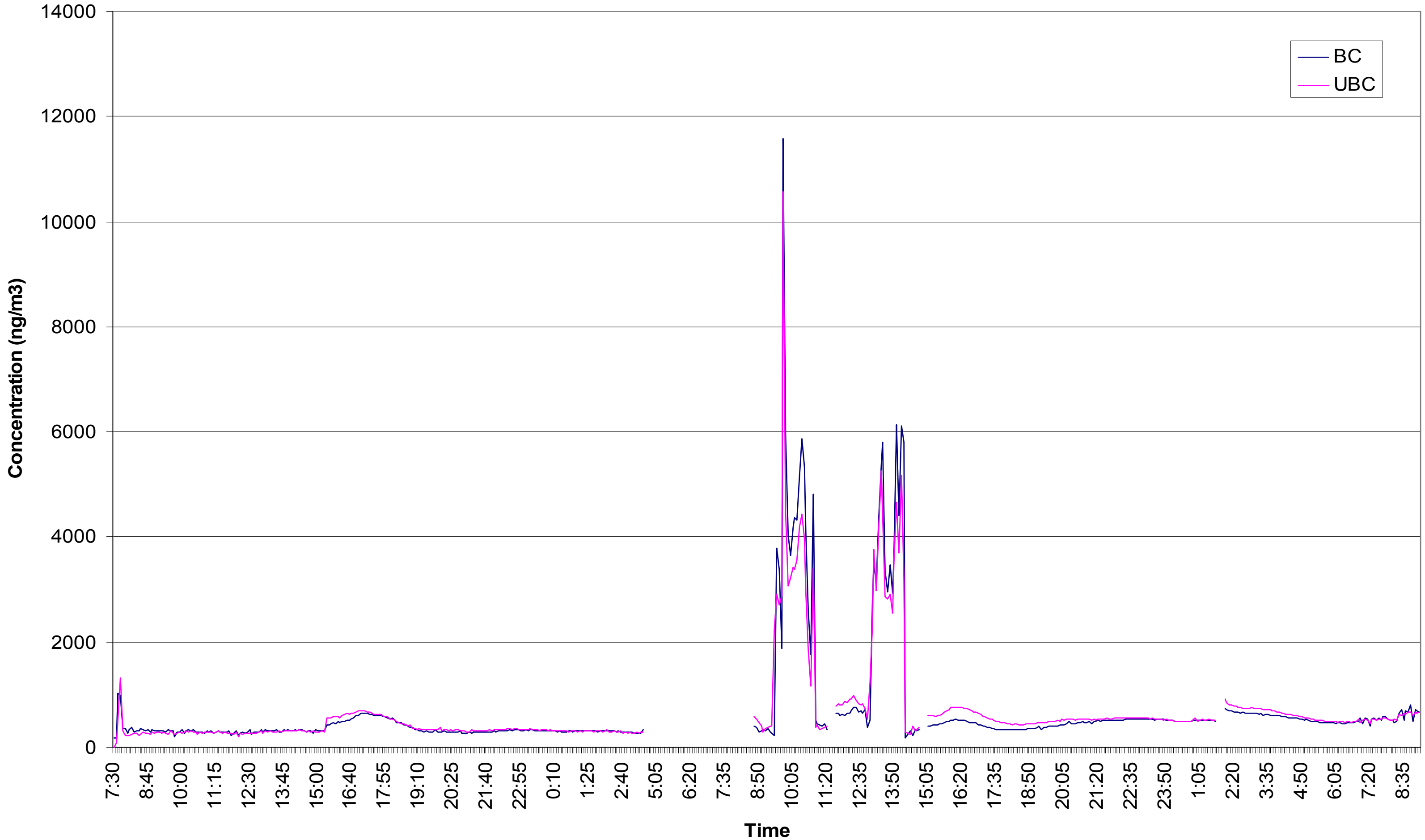
- “Exposure efficiency” studies
- SCOPE studies [Sources and Composition of Particulate Exposures]
- St. Louis Bus Study

Fine Particulate Concentrations
Trip 1, March 11-13, 2002: St. Louis, MO
Senior Citizens



Black Carbon Concentrations

Trip 1, March 11-13, 2002: St. Louis, MO



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Issues Raised

- Importance of peak exposures
- Importance of components

"Exposure Efficiency"

A Regression-Based Approach for Estimating Primary and Secondary Particulate Matter Intake Fractions

Jonathan I. Levy,[1*] Scott K. Wolff,[1] and John S. Evans[1]

Table 1. Intake Fraction Summary Statistics for Power Plants and Mobile Sources

Source	Pollutant	Mean[1]	Standard Error of Mean	Minimum	Maximum
Power plant	Primary $PM_{2.5}$	2.2×10^{-6}	1.9×10^{-7}	2.5×10^{-7}	6.3×10^{-6}
	SO_2/ammonium sulfate	2.2×10^{-7}	8.2×10^{-9}	8.3×10^{-8}	3.0×10^{-7}
	NOx/ammonium nitrate	3.5×10^{-8}	1.3×10^{-9}	9.6×10^{-9}	7.5×10^{-8}
Mobile source	Primary $PM_{2.5}$	9.1×10^{-6}	6.4×10^{-7}	1.2×10^{-6}	1.8×10^{-5}
	SO_2/ammonium sulfate	1.8×10^{-7}	8.7×10^{-9}	4.8×10^{-8}	3.0×10^{-7}
	NOx/ammonium nitrate	3.1×10^{-8}	1.8×10^{-9}	5.3×10^{-9}	6.6×10^{-8}

Note: Derived from Wolff, 2000.
[1]Weighted average of intake fraction estimates, weighted according to the relative emission rates in each of the four geographic strata (midwest, northeast, south, and west).

Quantities of pollutants emitted important

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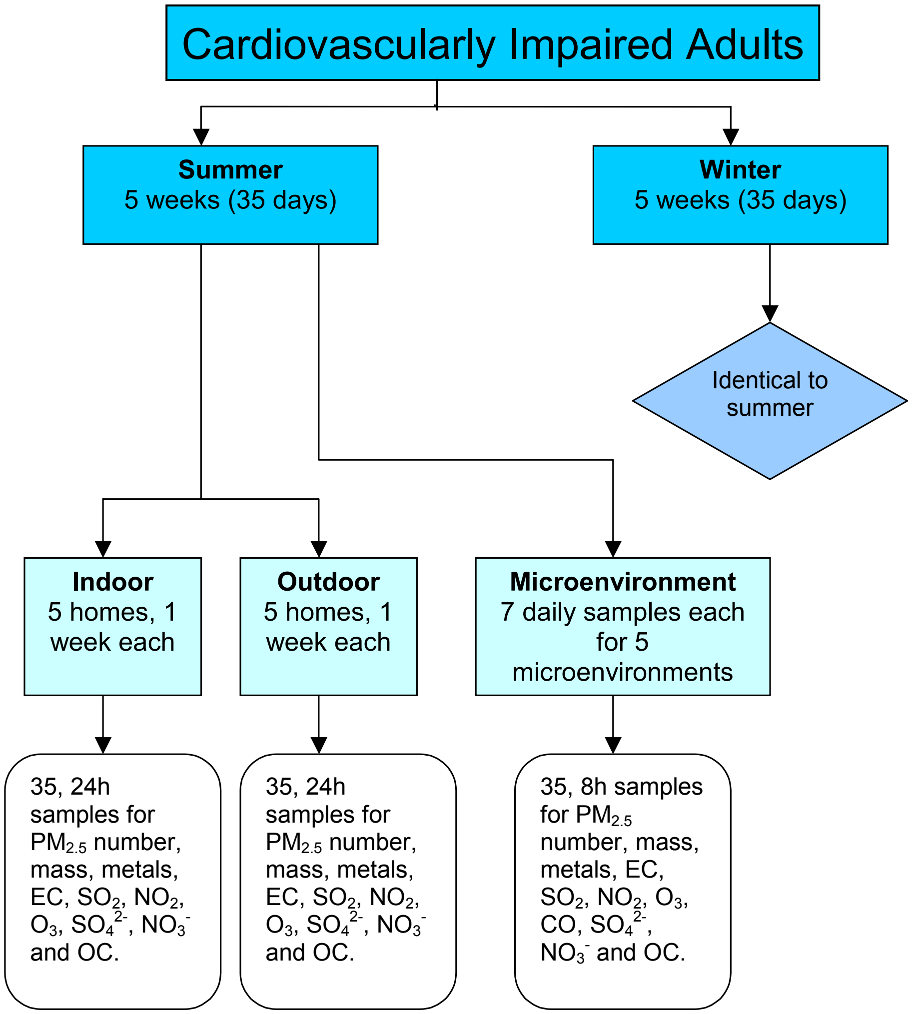
SCOPE

- Select sensitive populations
- Assess activity profiles by environment
- Sample environments by components
- Estimate personal exposure by components

Atlanta SCOPE



Epidemiology

- Components vs. Sources
  - Ambiguity of source signatures
  - Identification of “bad actors”
  - Chemistry influence on secondary pollution formation
- Components
  - ? Comprehensiveness ($)
  - Multicollinearity

ARIES Program

- Combines detailed monitoring with several health endpoints

- Studies underway
  - Atlanta
  - St. Louis
  - Dallas
  - Detroit
  - Birmingham
  - NYC

ARIES Study: Atlanta

- **ARIES**
  - **Atmospheric Measurements**
    - Atmospheric Research & Analysis
    - U. of Minnesota
    - Desert Research Inst.
    - Oregon Graduate Inst.
  - **Spatial Variability**
    - Georgia Tech
    - Emory University
    - Harvard University
  - **Daily Mortality**
    - Klemm Analysis Group
  - **Emergency Visits**
    - Emory University
  - **Arrhythmic Events**
    - Emory University
  - **Urgent Care Visits (HMO)**
    - Kaiser Permanente
  - **Heart Rate Variability (Personal Exposure)**
    - Harvard University

ARIES: Cardiovascular Endpoints (lag 0-1 day), Updated (up to 53-month) results

	Unscheduled Physician Visits: Total CVD	Emergency Room Visits: Total CVD	ICD Response	CVD Mortality	Panel Study HRV	
					Ambient	Personal
Ozone						
NO_2						
CO						
SO_2						
OHC						
PM_{10}						
PM_{coarse}						
$PM_{2.5}$						
Ultrafines						
SO_4						
Acidity						
EC						
OC						
Metals						

Significant +ve association
No significant association
Significant –ve association
Preliminary + ve association

* lag 3-5 days **4-hour avg. conc.

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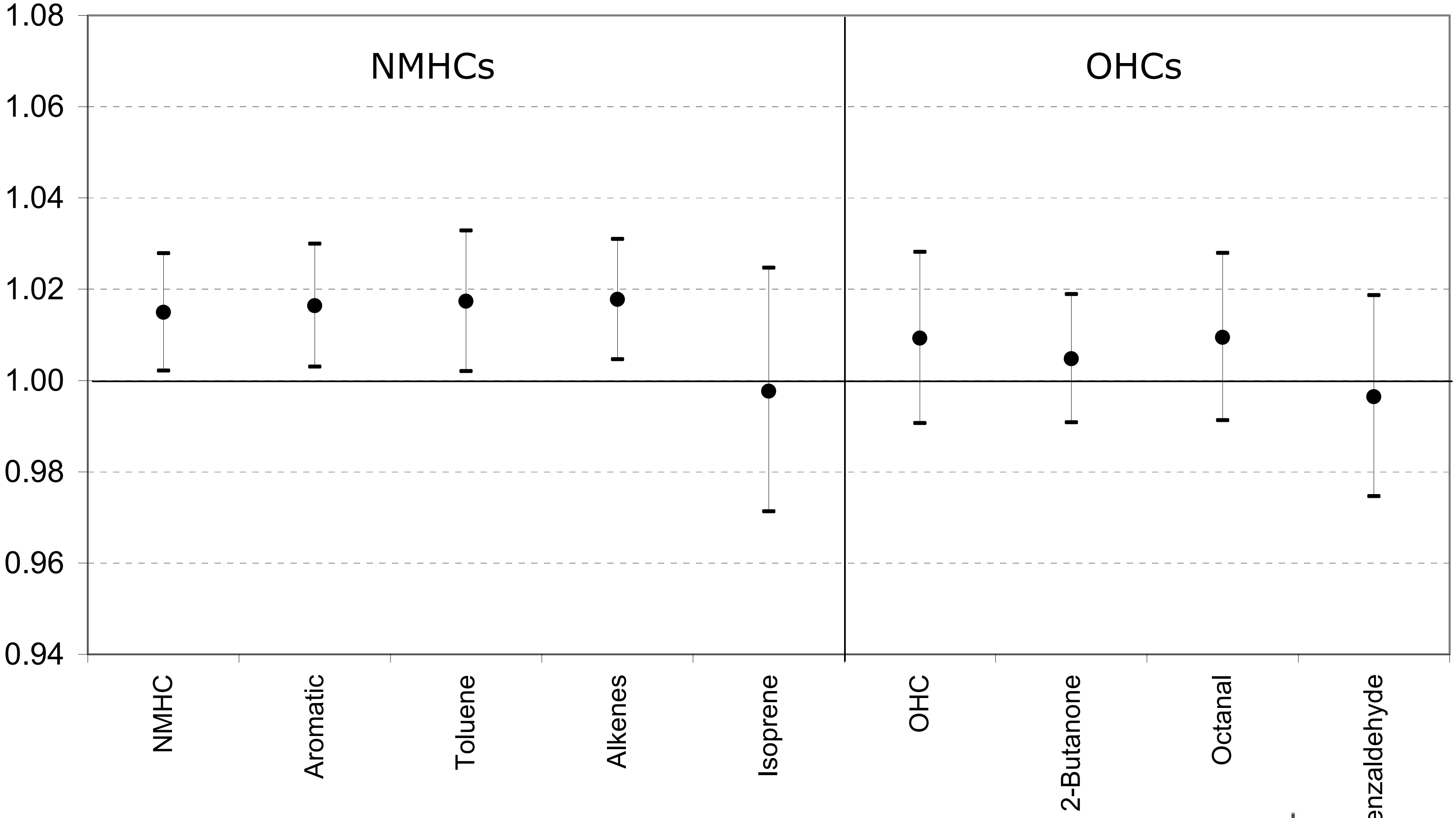
ED Visits for All Cardiovascular Disease



Summary: Cardiovascular ED Visits

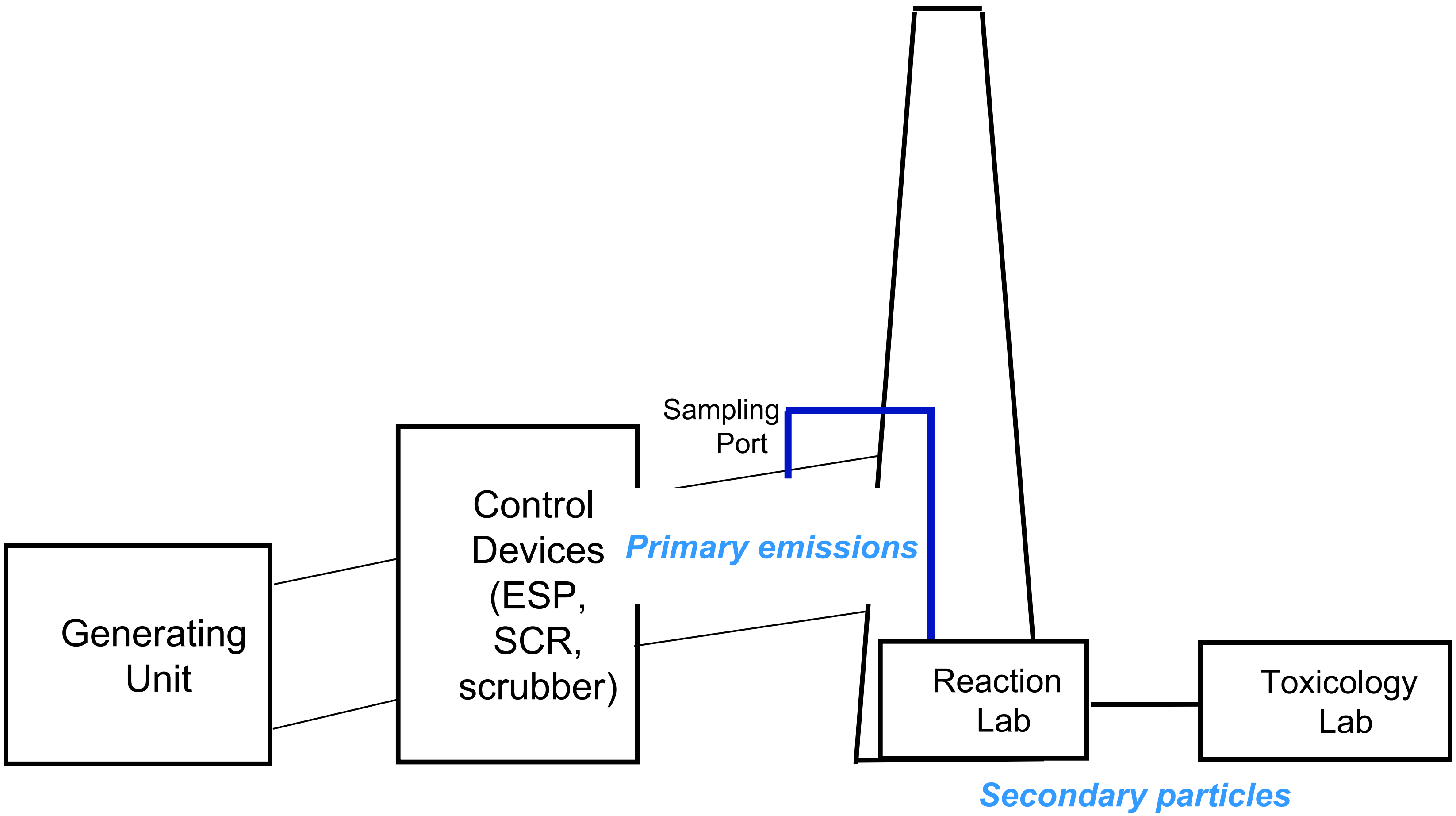
- Significant positive effects between cardiovascular ED visits and 24-hr VOC concentrations

- Associations highest for
  - Ischemic heart disease (IHD), myocardial infarction (MI) and congestive heart failure (CHF) ED visits
  - NMHCs, aromatics (toluene), alkenes
  - OHCs, 2-butanone

Respiratory ED Visits: Significant Results

- Asthma- none
  - Entire year: none
  - Summer period: NMHCs; alkenes, alkanes, PM_{10}; O_3, NO_2; $PM_{2.5}$; OC; EC
- Upper respiratory disease:
  - Entire year: PM10; O_3; NO_2; CO
  - Winter period: NMHCs
- Pneumonia- none
- COPD: several significant associations (entire year)
  - Non-methane hydrocarbons
  - Alkanes
  - Aromatic compounds
  - Toluene
  - Alkenes (not isoprene)
  - NO_2
  - CO

Toxicology
TERESA (*Toxicological Evaluation of Realistic Emissions of Source Aerosols*): Field Layout



Three Plants in Program

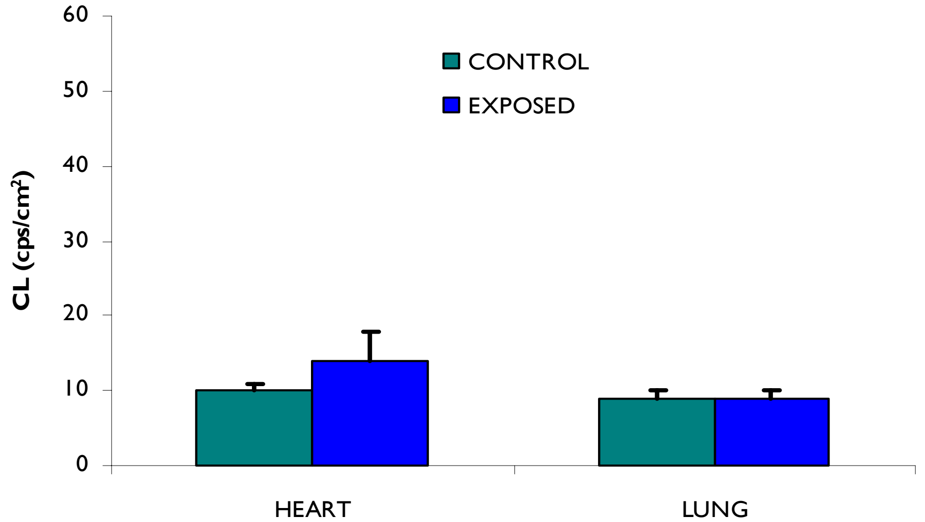
1. Midwest: Powder River Basin coal (low sulfur, low ash), no SCR for NOx removal. Fieldwork completed November 2004.

2. Southeast: Low sulfur (<1%) eastern bituminous coal, no scrubber for SO_2 removal, with SCR. Fieldwork completed September 2005.

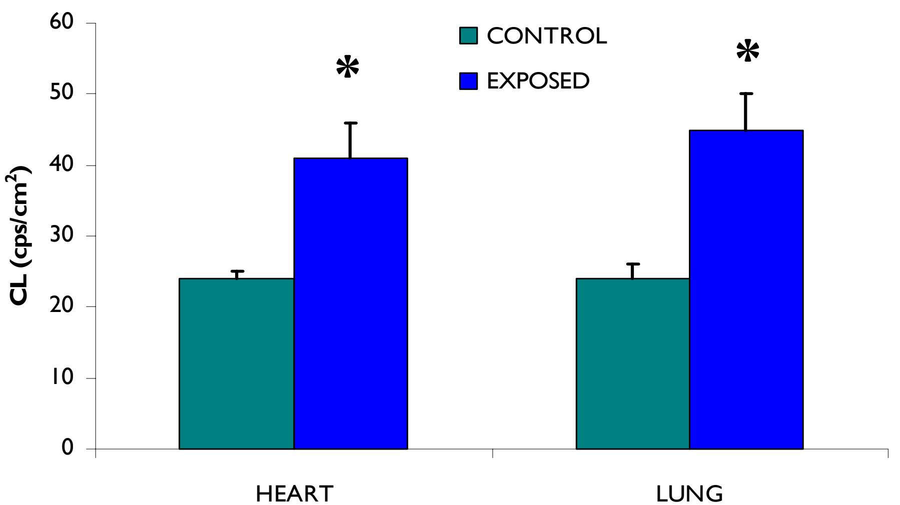
3. Midwest: Medium-to-high sulfur (>2-3%) eastern bituminous coal, scrubbed unit, with SCR. Fieldwork in July-September 2006.

Plant 1 Results: Oxidative Stress in Heart and Lung Tissue

TERESA: Power Plant Emissions



Boston Particles (Gurgueira *et al*., 2002)

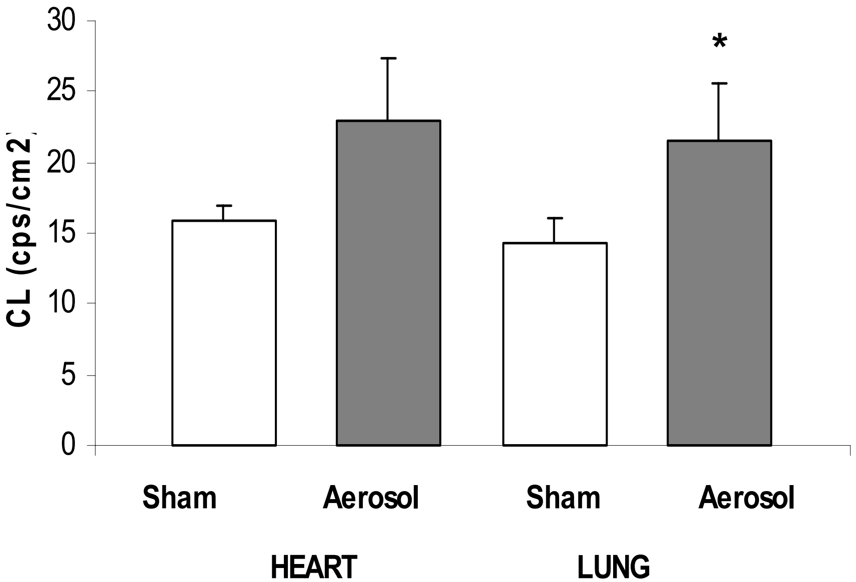


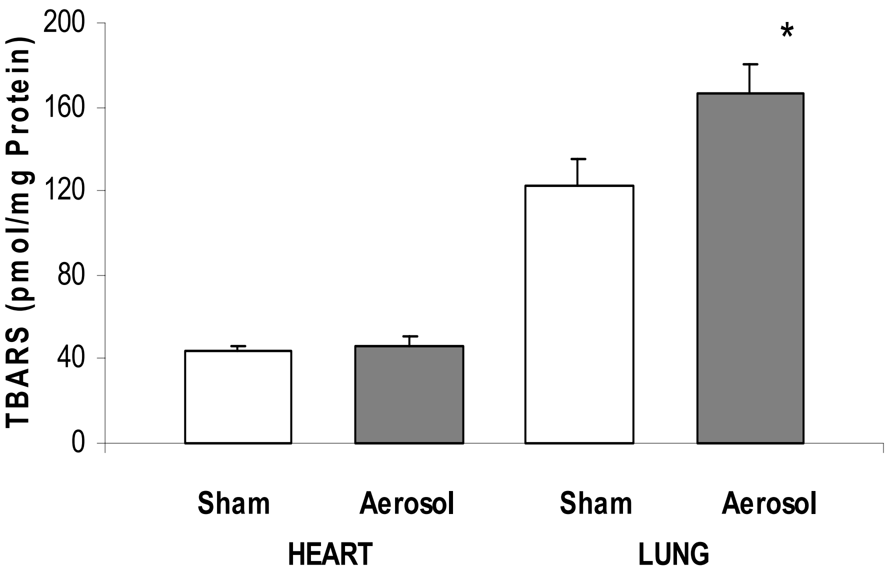
Concentrations of Selected Components

Scenario	P		PO		POS		PONS	
Plant	P1	P2	P1	P2	P1	P2	P1	P2
$PM_{2.5}$	-0.2	2.5	58	223	138	394	174	474
OC	24	42	23	17	86	80	73	64
Sulfate	0.7	0.4	32	101	57	139	71	156
Acidity	1.2	0	23	72	49	106	13	16

Plant 2: Oxidative Stress in Heart and Lung Tissue

Primary emissions + oxidized + secondary organic aerosol (*n*=8 in each group)





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Oxidative Stress: GLM Output

Scenario	P		PO		POS		PONS	
Ind. Plants	P1	P2	P1	P2	P1	P2	P1	P2
CL Lung	NS	NS	NS	NS	NS	↑ **0.005**	NS	NS
CL Heart	NS	NS	NS	NS	NS	↑ **0.006**	NS	↑ **0.07**
Combined	P		PO		POS		PONS	
CL Lung	NS		NS		↑ **0.05**		↑ **0.012**	
CL Heart	NS		NS		↑ **0.002**		↑ **0.03**	

P = Primary

PO = Primary Oxidized

POS = Primary Oxidized + Secondary Organics

PONS = Neutralized POS

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Toxicology!
Conclusions, Musings, and What's Next

- Slightly higher primary particle concentrations at Plant 2; different compositional profile
- Higher secondary PM concentrations at Plant 2
- Cardiac and pulmonary effects observed at Plant 2
- See most effects in scenarios with secondary organics
  - Effect of SOA alone? Probably not.
  - Interaction of SOA with component of mixture?
  - Additive/synergistic effect?
- Ongoing analyses to understand the significance of the differences between the plants/scenarios
- Plant 3 fieldwork underway

Overall Conclusions

- Role of organics
- Little with sulfates per se
- Gases can be important
- ? Interactions with organics
- Need more characterization within epidemiological studies
- Toxicological/epidemiological interface
  - More innovative designs