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Building a scientific foundation for sound environmental decisions

PRELIMINARY EXPOSURE FINDINGS ASSOCIATED WITH THE DEARS

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US EPA's Office of Research and Development

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The Detroit Exposure and Aerosol Research Study (DEARS)

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- Roy Fortmann
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US EPA

- Charles Rodes, Jonathan Thornburg (RTI International)
- Kathy Edgren (Univ of Michigan & the CAAA)
- MaryAnn Heindorf, Ann Chevalier, Dan Ling, Jason Wolf and other staff from the Michigan Department of Environmental Quality

Personal Exposure – Key Questions

- What are the relationships between PM concentrations measured at ambient sites and indoor, outdoor, and personal exposure
- Can PM measurements at central sites adequately represent exposures to ambient PM?
- Do the relationships differ for toxic components of PM?
- Can models be used to improve estimates of exposure from ambient site measurements?
- Can models be used to better understand the relationships between PM sources, ambient air concentrations, and personal exposure?

DEARS- GOAL

- Describe the relationship between concentrations at a central site and residential/personal concentrations for
  - PM constituents
  - PM characteristics
  - PM from specific sources (mobile and point)
  - Air toxics

Study Design Factors

Emphasis placed on understanding impact of:

- Local sources (mobile and point) on outdoor residential concentrations,
- Housing type and house operation on indoor concentrations
- Locations and activities on personal exposure

Factors Influencing Primary Study Areas

- Age and housing stock
- Proximity to line and point sources
- Meteorology
- Season
- Personal and household factors (time activities and home operation)

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Current Exposure Monitoring Areas

Neighborhood Selection Criteria

		Mobile Source				
		None	Gas, driving	Gas, stop and go	Diesel, driving	Diesel, idling
Point Source	None	#7***	#5***	#6*	--	--
	Oil, steel, power	#1*	--	--	#4**	#3*
	Coal, incinerators, steel	#2*	--	--	--	--

* Homes generally older than 1980, ** mix of homes although mostly older, ***homes built after 1980

Field Monitoring Design

- 3 year study started in Summer 2004
- Collect data in 120 homes for 5 days in winter and 5 days in summer (1200 sampling days
- Concurrent monitoring at
  - Central site
  - Residential – outdoors and indoors
  - Personal level
- Survey data
  - Residential characteristics, participant characteristics, time/activity, source usage.

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Sampling Design

Parameter	Personal	Indoor	Outdoor	Ambient
$PM_{2.5}$ (mass, elements)	x	x	x	x
PM_{coarse} (mass, elements)	--	x	x	x
EC-OC ($PM_{2.5}$)	--	x	x	x
EC ($PM_{2.5}$)	x	x	x	x
Nitrate	--	x	x	x
Gases	x	--	-NO_2	x
Carbonyls	x	x	x	x
VOCs	x	x	x	x
SVOCs	--	x	x	x
PAHs	--	x	x	x
Air Exchange Rate	--	x	--	--

Sampling Vest

- Personal monitoring vest
- Time Activity Diary
- 5 days, 2 seasons

Indoor & Outdoor Monitoring

- Matched to personal and ambient instrumentation

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Central Community Site Monitoring

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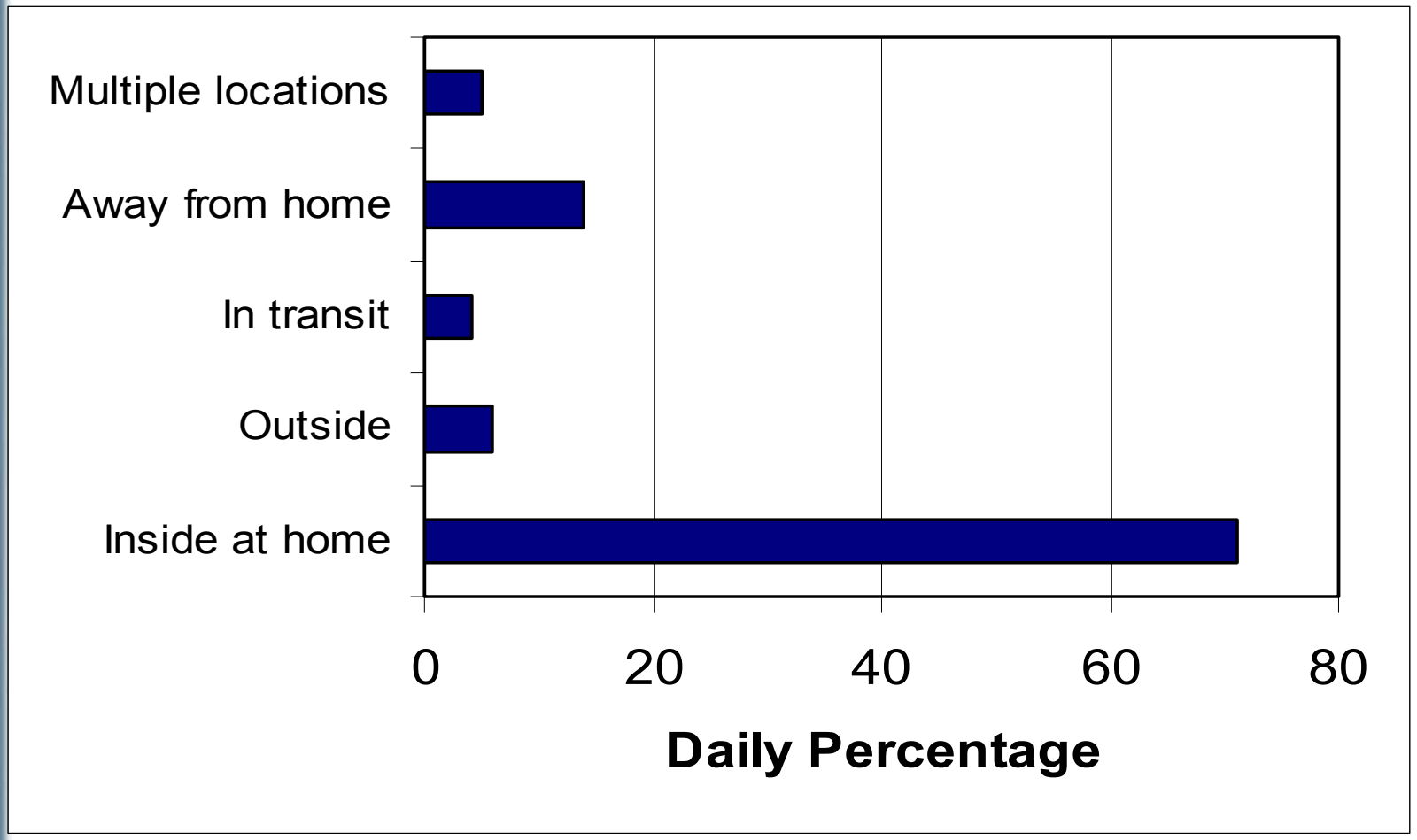
Seasonal Data Collection Rates (%)

Metric	~Nominal attempts	Summer '04	Winter '05	Summer '05
PM	800-1930	97	98	96
EC-OC	470-560	93	96	99
Nitrate	460-560	93	93	94
Gases	820-1020	100	99	99
Carbonyl	680-770	99	99	98
VOC	720-870	99	99	98
MIE	600-660	<60	92	96
SVOC	450-540	95	94	97
PFT	190-210	100	100	98

Demographics

Home	Mean	Min	Max
Age (yrs)	58	6	125
Type	-84% single dwelling -5% modular -8% duplex with separate entries and HAC -3% other		
# residents	3.6	1	8
# of children	1.5	0	6
Age of children	10.4	3	17
-65% had children under 18 y.o. -73% had 2 or more adults at home			

Mean Activity Patterns



Commute statistics	-16/38 commuted regularly (car, bus) -averaging 18 minutes per trip -maximum commute was 30 minutes

Demographics

	N (38)	Mean	Min	Max
Sex	27% male 73% female	--	--	--
Age (years)	5 ≥ 65 19 ≤ 40	49	19	79
Weight (lbs)	16 >200* lbs	195	115	312

*Indicates a group that might have somewhat reduced levels of physical activities

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Year 1 Residence Survey

Factor	%	Mean (STD)	Min	Max
Central AC	29			
Window AC	58			
Attic fans	5			
Storm windows	68			
Cook w/gas	82			
Vented clothes dryers	87			
Used humidifiers	24			
Recently painted (< 7 days)	13			
New carpet (< 6 months)	8			
New wallboard (<6 month)	32			
Air exchange/hr (summer)	N= 187	2.1(2.4)	0.1	17.0
Air exchange/hr (winter)	N= 175	1.2(0.8)	0.2	3.7

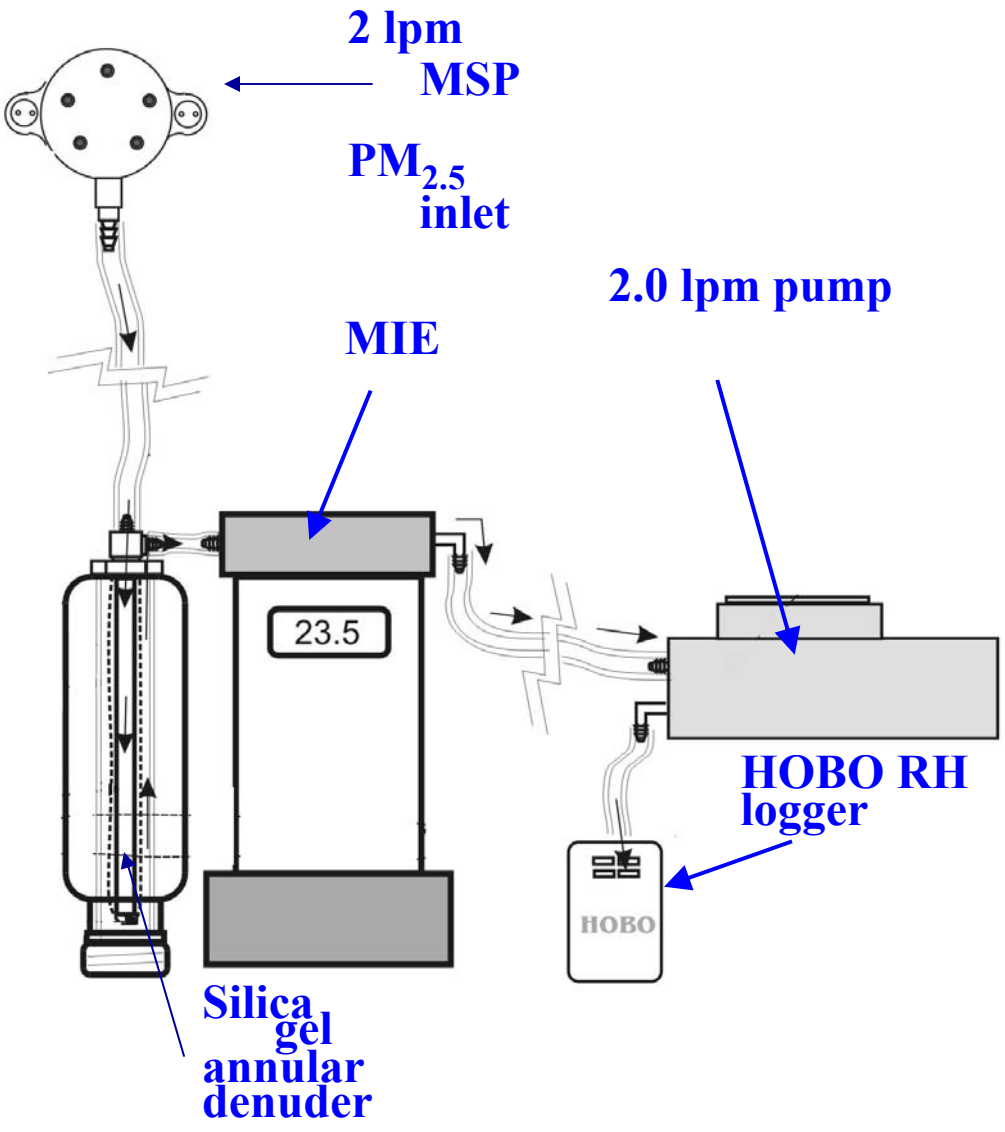
Meteorology

Metric	Summer '04 mean (STD)	Winter '05 mean (STD)
Temperature (°C)	21.2 (3.2)	1.0 (4.5)
Wind speed (mph)	4.2 (1.5)	6.5 (2.7)
Wind direction (degrees)	262.6 (0.8)	259.6 (0.9)
Magnitude of wind vector	3.6 (1.8)	5.1 (3.0)

Novel Exposure Monitoring

- Coarse particle Personal Exposure Monitor (CPEM)
- RH-Denuded Active PM2.5 Personal Nephelometer
- Perkin-Elmer passive VOC tube
- PAKS passive Carbonyl tube

DEARS Active MIE Sampling System



Personal
MIE system
in vest pocket

Passive Diffusion Samplers

- Diffusive samplers used to measure 25 VOCs
- Aromatics/HCs (9)
  - Ex: BTEX, 1,3-butadiene, styrene
- Halogenated HCs (16)
  - Ex: Freon 11,113,114, perc., [m,o,p]-dichlorobenzene, trichlorofluoromethane
- Detection limits ~ 0.02-0.5 ppb

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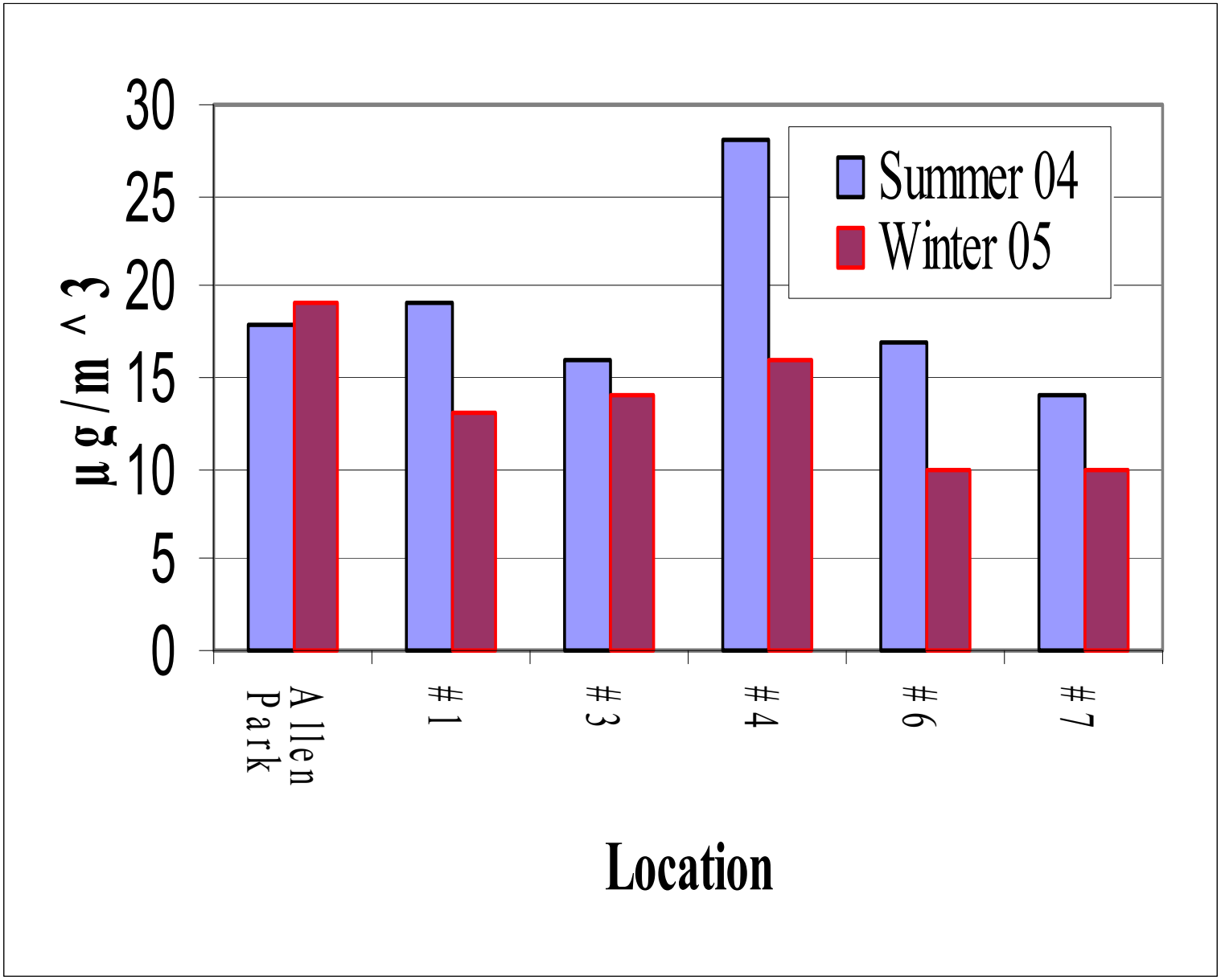
Mean Personal PM2.5 Data ($\mu g/m^3$)



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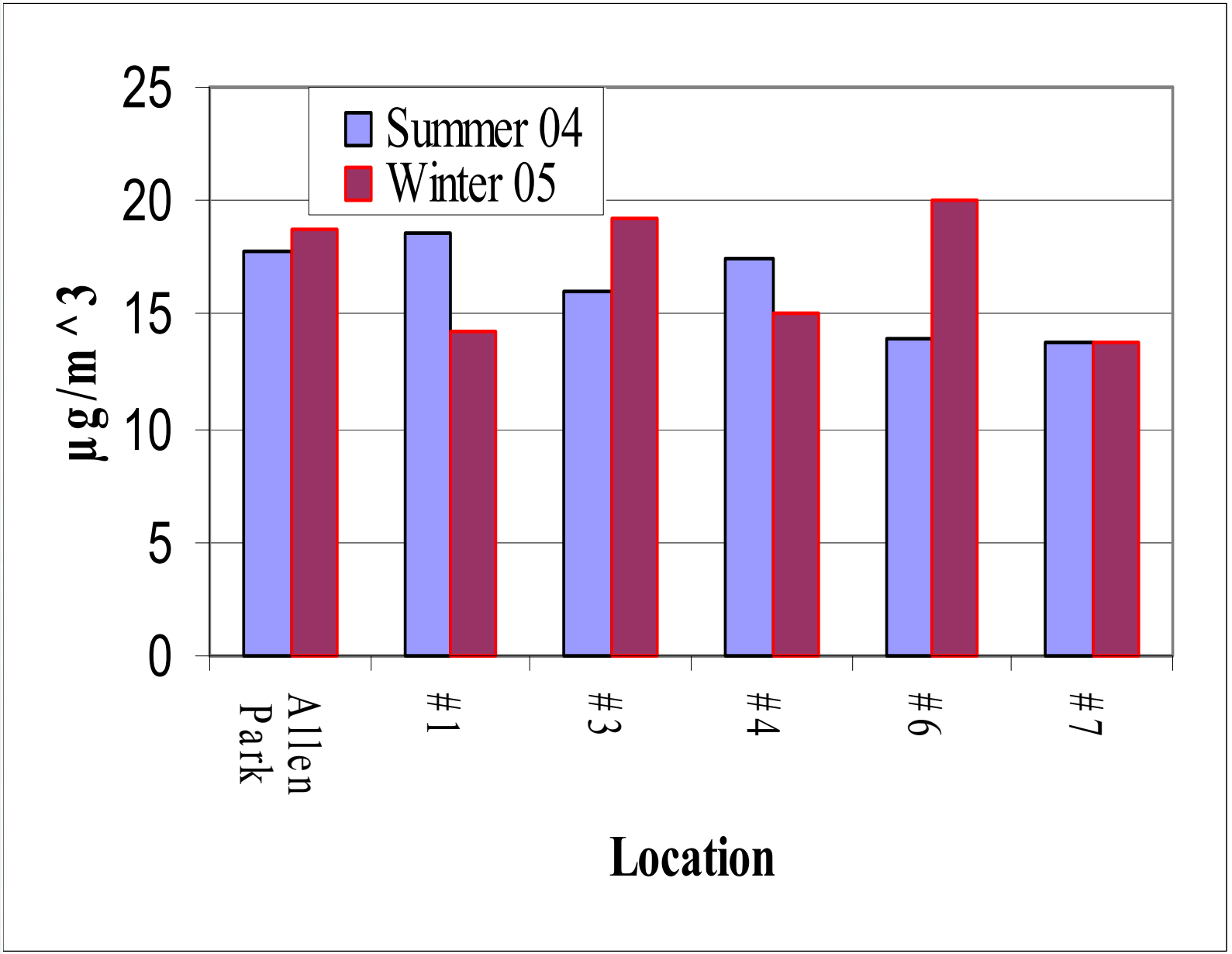
Mean Outdoor PM2.5 Data ($\mu g/m^3$)



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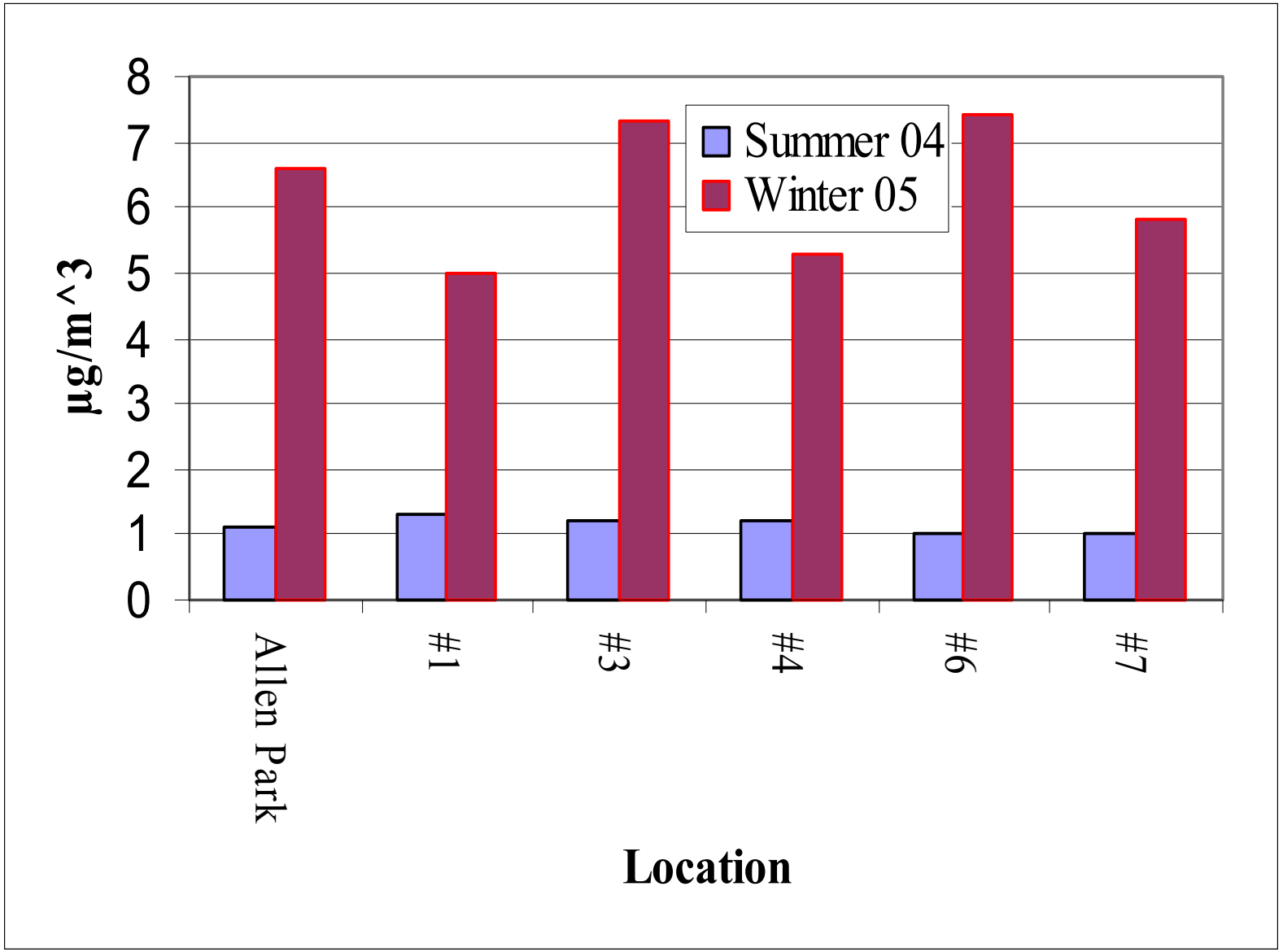
Mean Outdoor PM2.5 Nitrate Data ($\mu g/m^3$)



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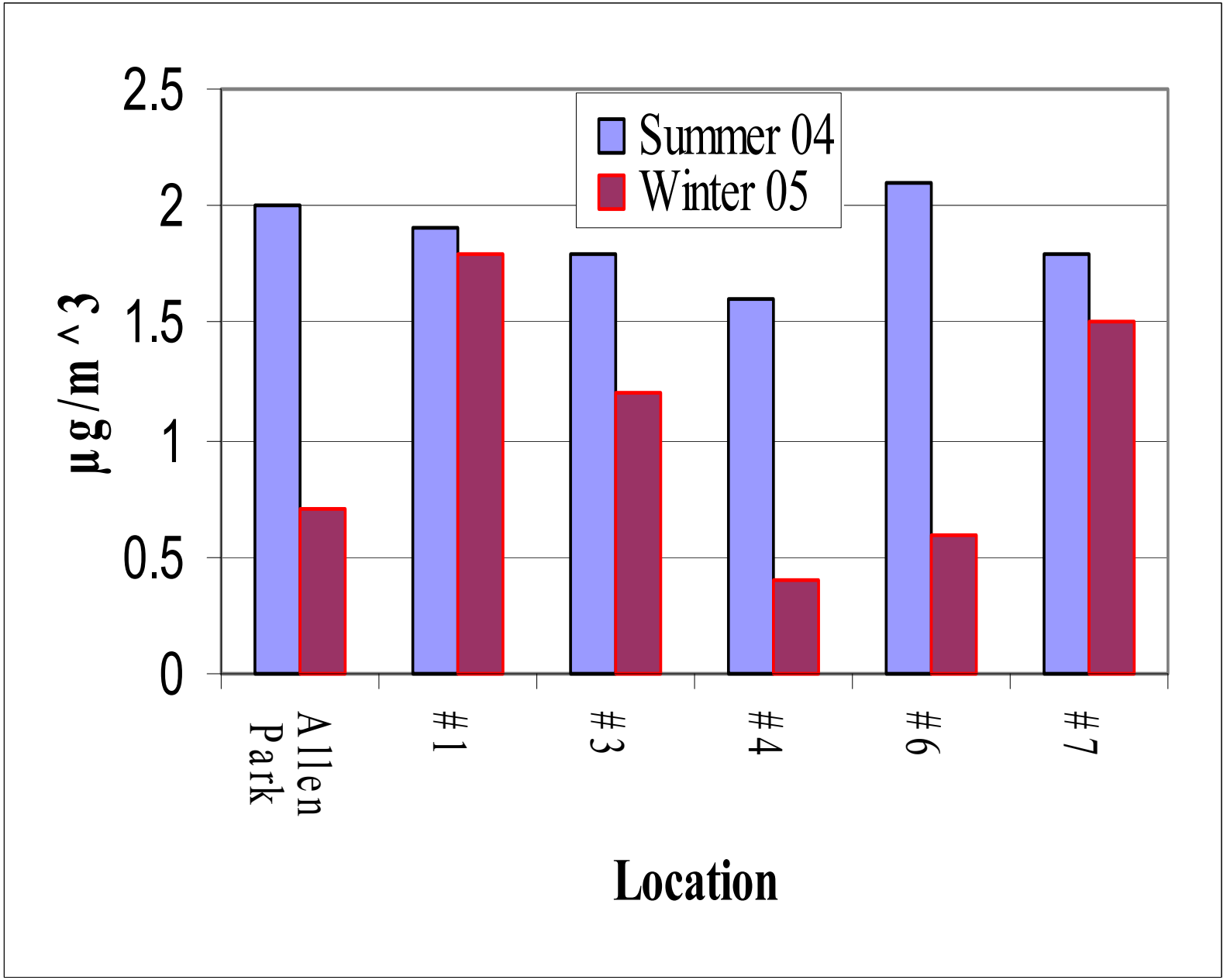
Mean Outdoor Acrolein (µg/m^3)



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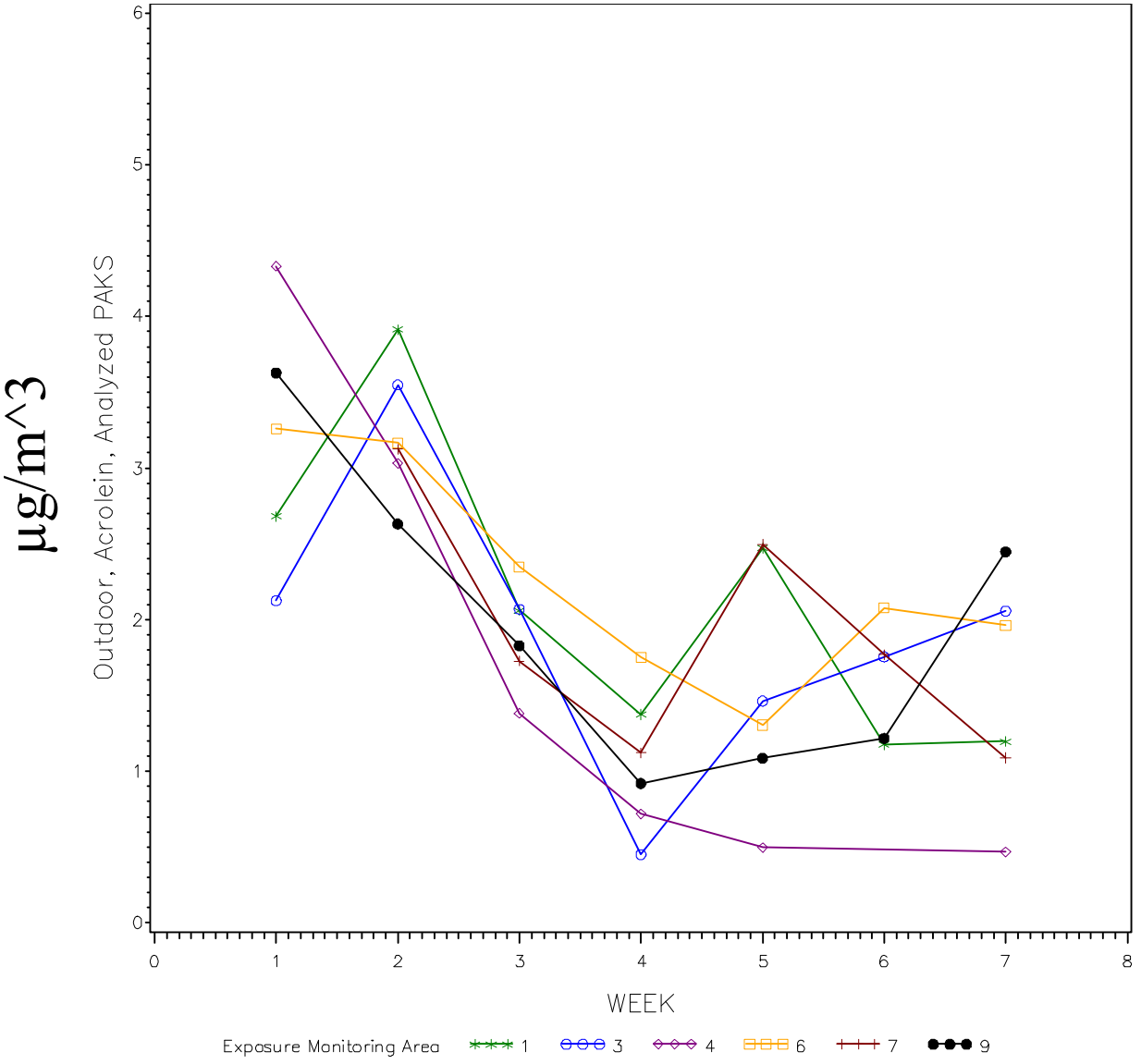
Acrolein Measured Outdoors



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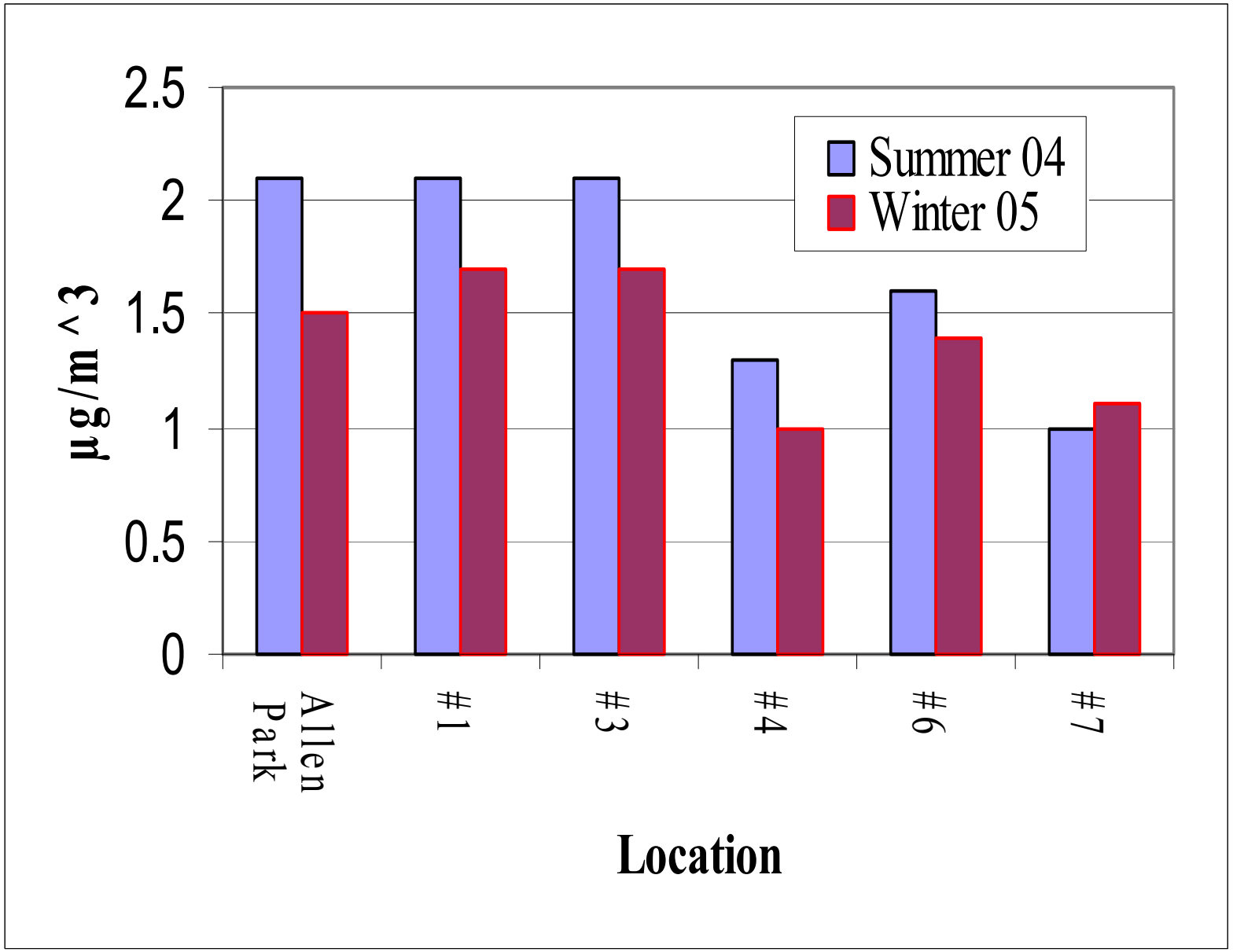
Mean Outdoor PM2.5 EC Data (µg/m^3)



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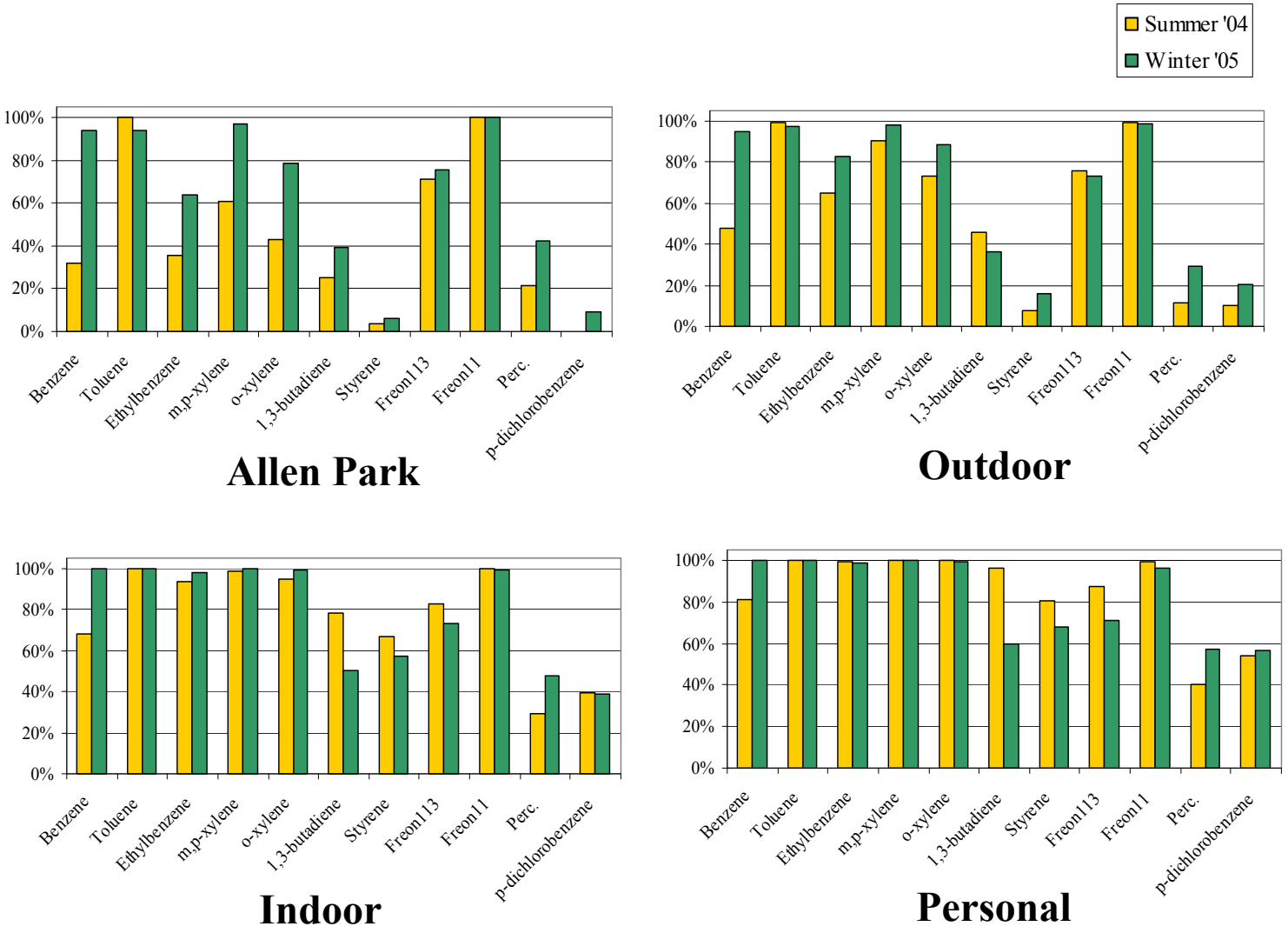
Detectible VOC Samples



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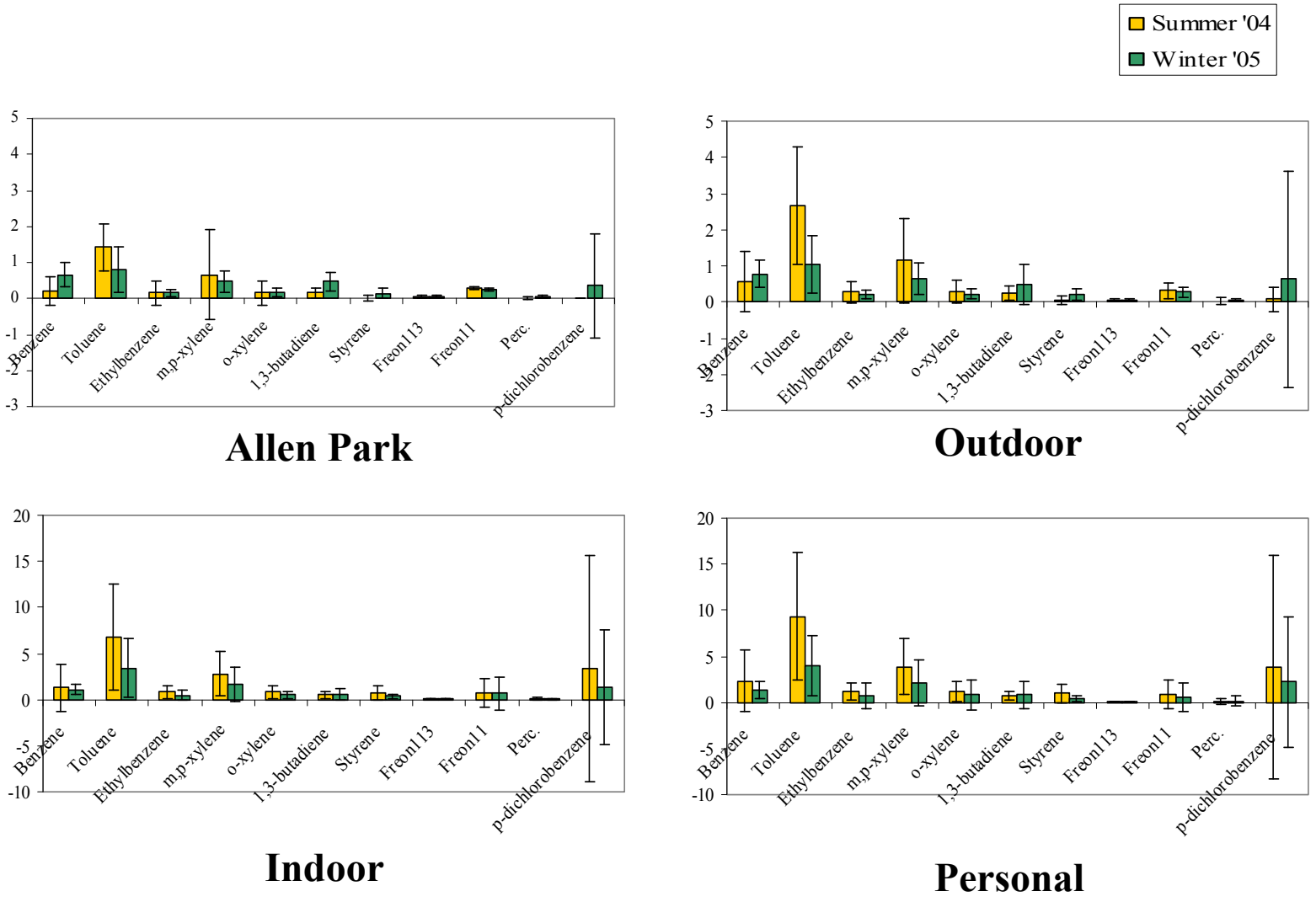
Seasonal Levels Across Microenvironments



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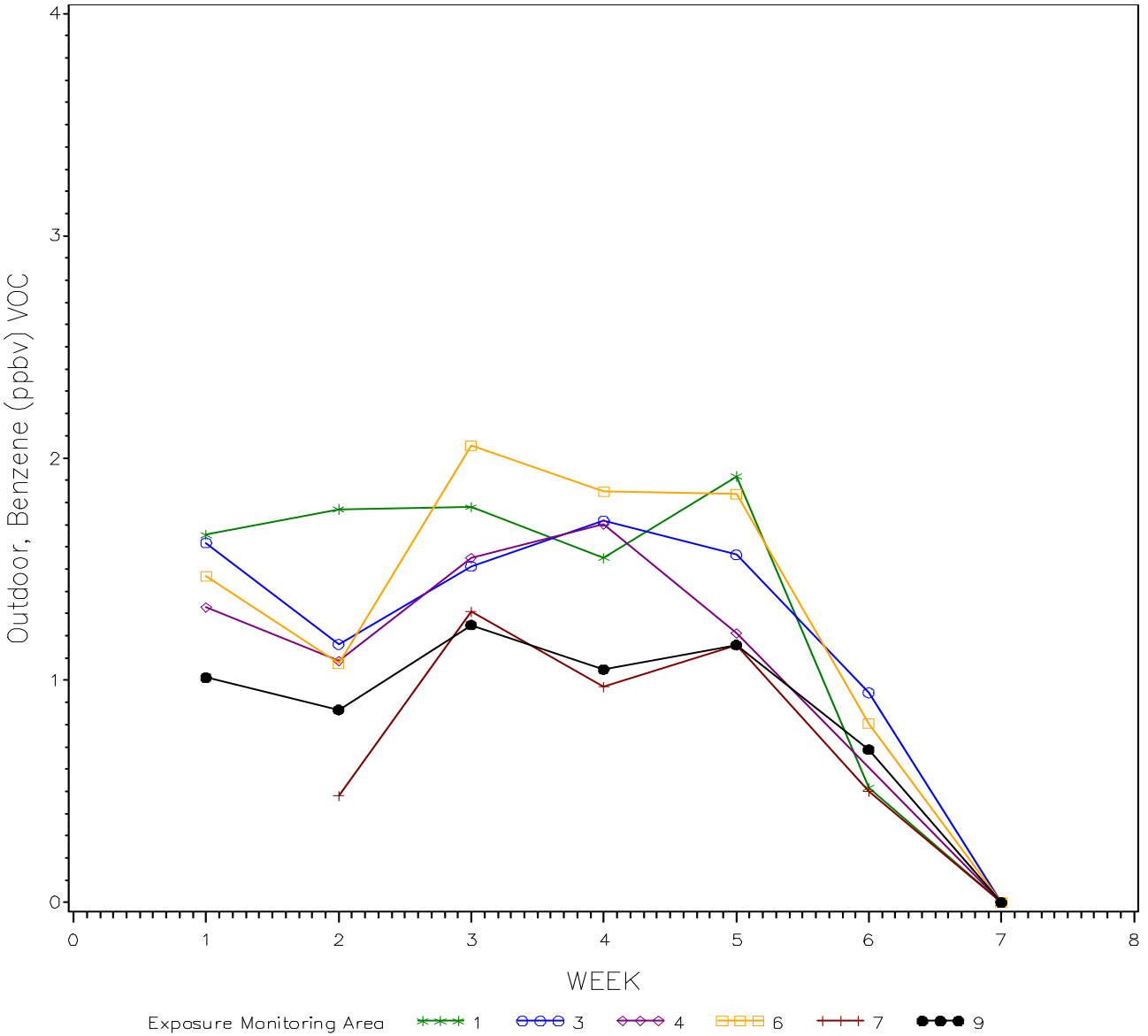
Benzene Measured Outdoors



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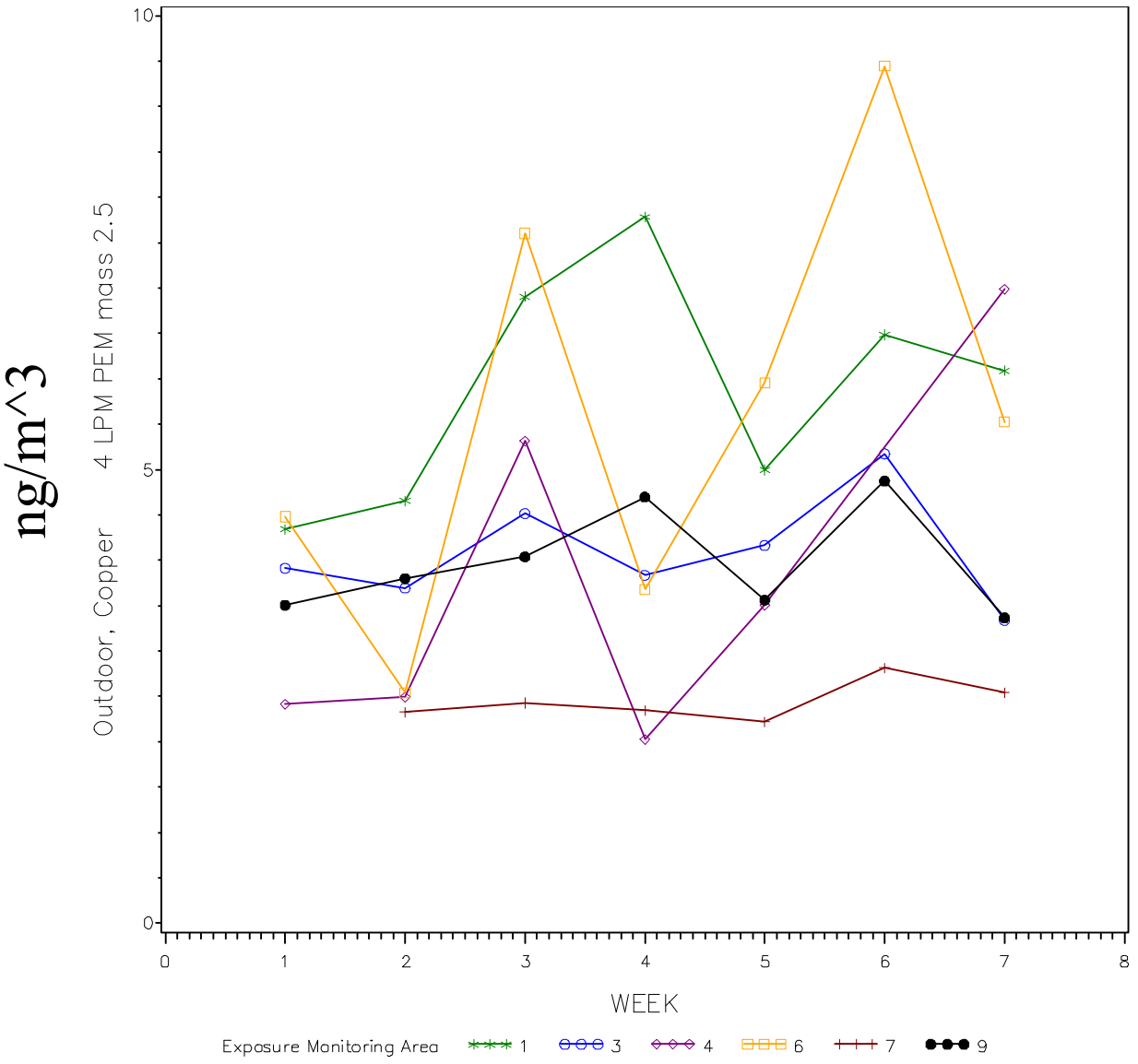
Copper Measured Outdoors



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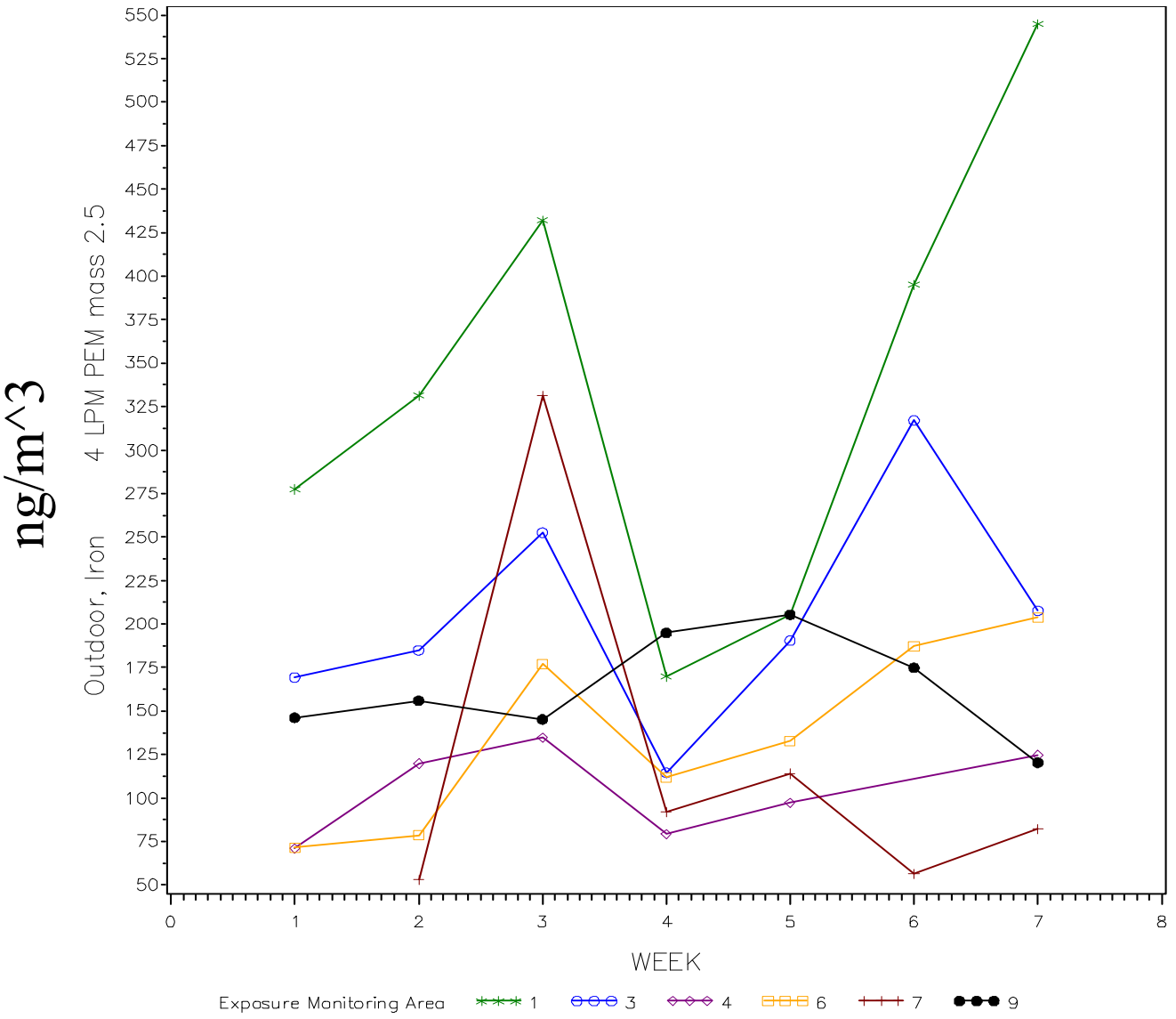
Iron Measured Outdoors



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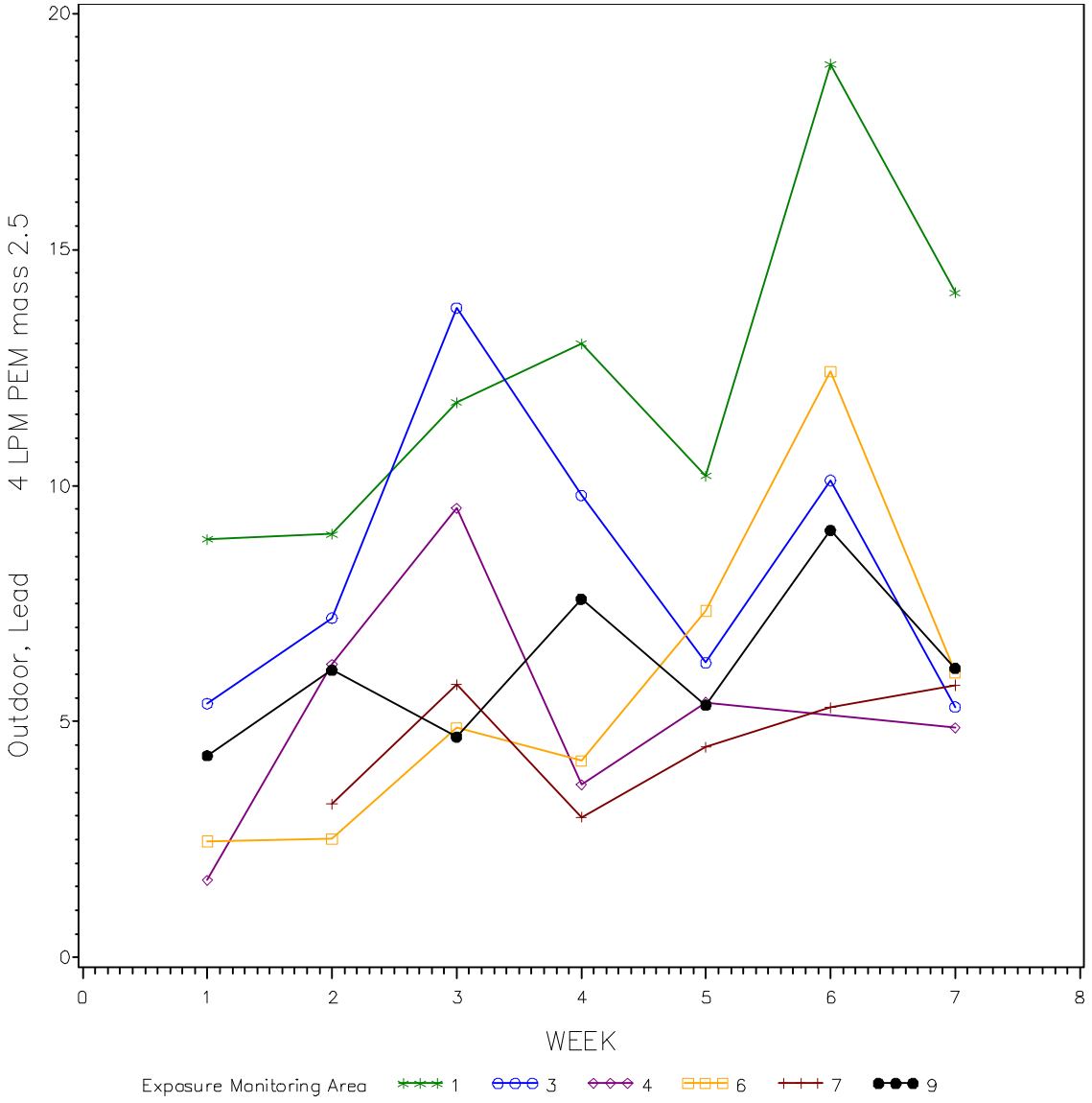
Lead Measured Outdoors

ng/m^3



Conclusions

- Preliminary data analyses indicate that agreement between community-based monitors and outdoor measurements from some neighborhoods and pollutants differ dramatically. Spatial and temporal variances are being observed.
- The DEARS study design has been shown to be a viable means of investigating spatially-related metropolitan areas.
- DEARS will provide data needed to estimate extremes of the personal exposure distribution of several health-critical pollutants
- Data from the DEARS holds the potential for providing novel information on personal and residential-based exposures to sources of ambient origin.

Conclusions

- Greater within-subject variability than between-subject variability
- Significant differences were observed in 16 of 23 species between the central site monitor and outdoor residential measurements
- Carbonyls were fairly consistent across neighborhoods
- Central site monitor may not be fully representative of potential exposure in adjacent neighborhoods

Disclaimer

Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy.

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