Characterization of Fine Particulate Matter at Elementary Schools in Central and Southeastern Ohio

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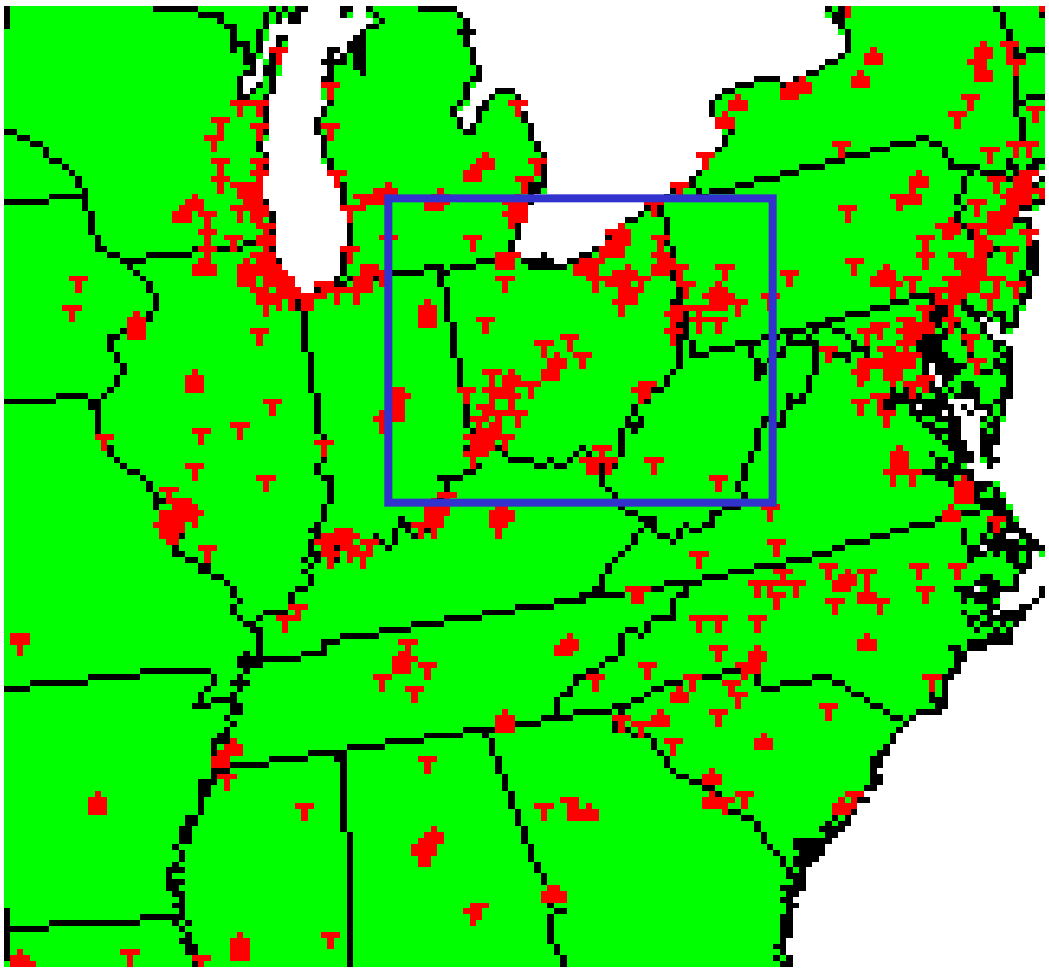
OBJECTIVES

- **Evaluate Air Quality**
  - **Regional, Seasonal, Daily**
  - **Meteorological Influence**

- **Correlation: Outdoor, Indoor, and Personal Exposures**

- **Correlation Between Health and Air quality**
  - **Prospective ($PM_{2.5}$, O_3, Health Data)**
  - **Retrospective (Criteria Pollutants, Health Data)**

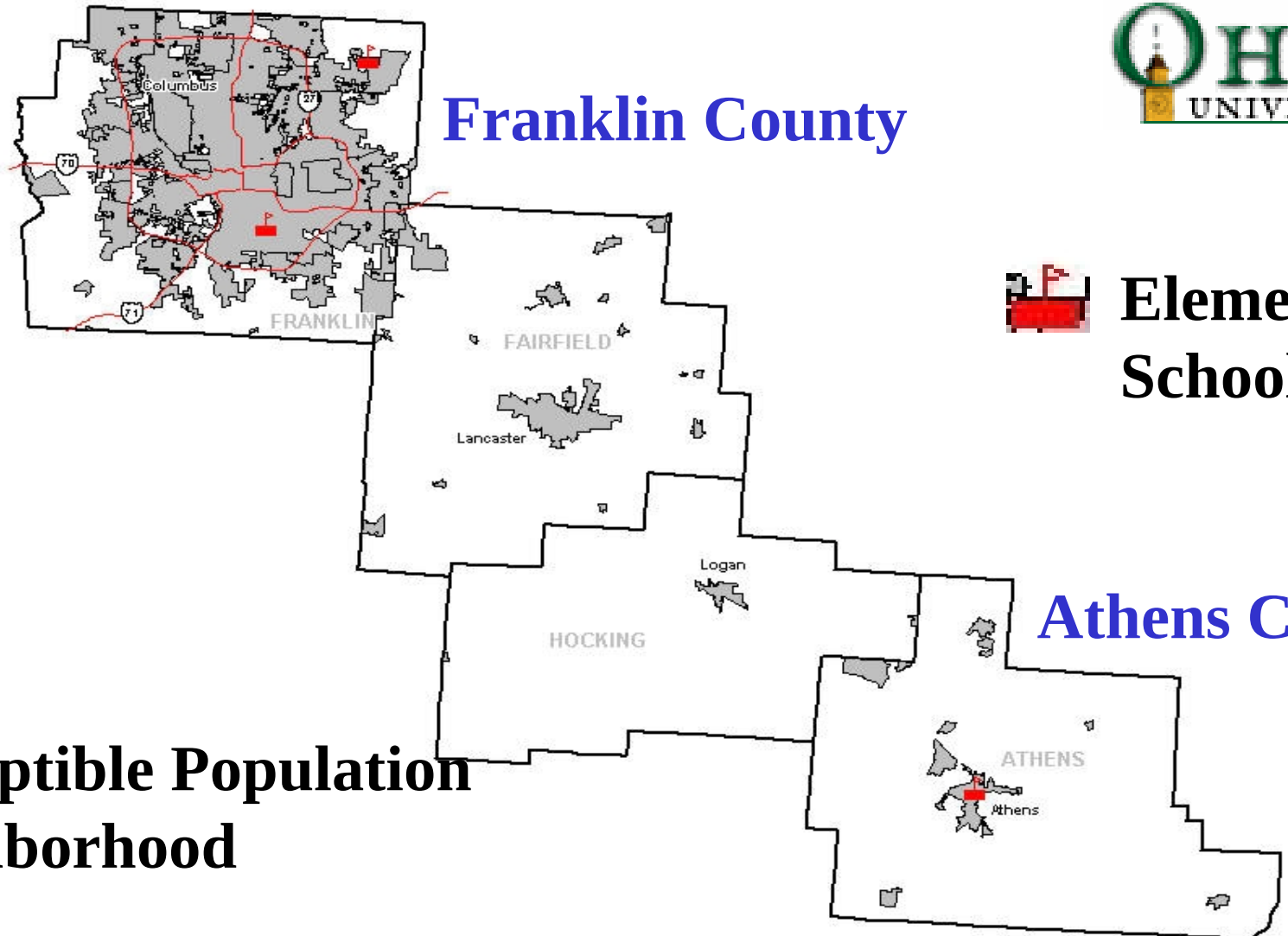
RETROSPECTIVE



Statistical Correlation
1992-1998
- Hospital Admissions over 300,000/yr
-Criteria Pollutants
(O_3,SO_2, NO_2...)

▽ **Ozone Monitors**

PROSPECTIVE STUDY



Franklin County

Athens County

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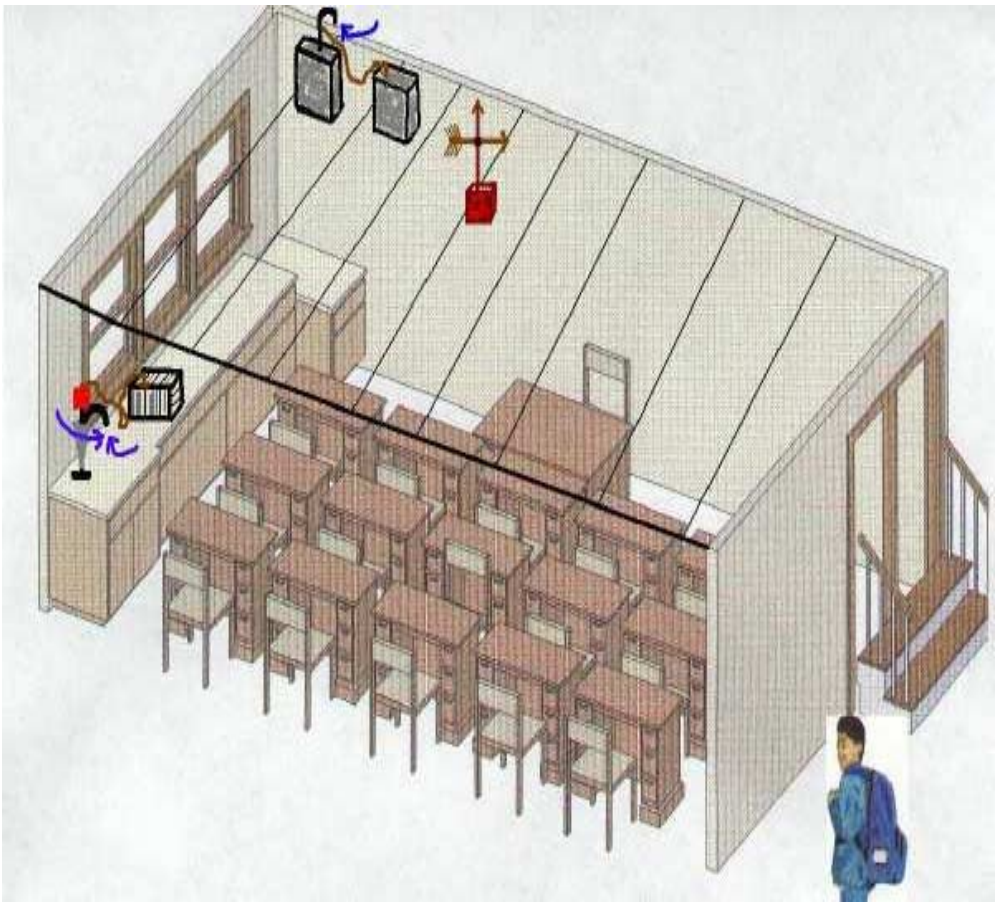
Elementary School

- Susceptible Population
- Neighborhood

MONITORING



- $PM_{2.5}$
  - Ambient
  - Indoor
  - Personal
- Meteorological
- Ozone

Installation

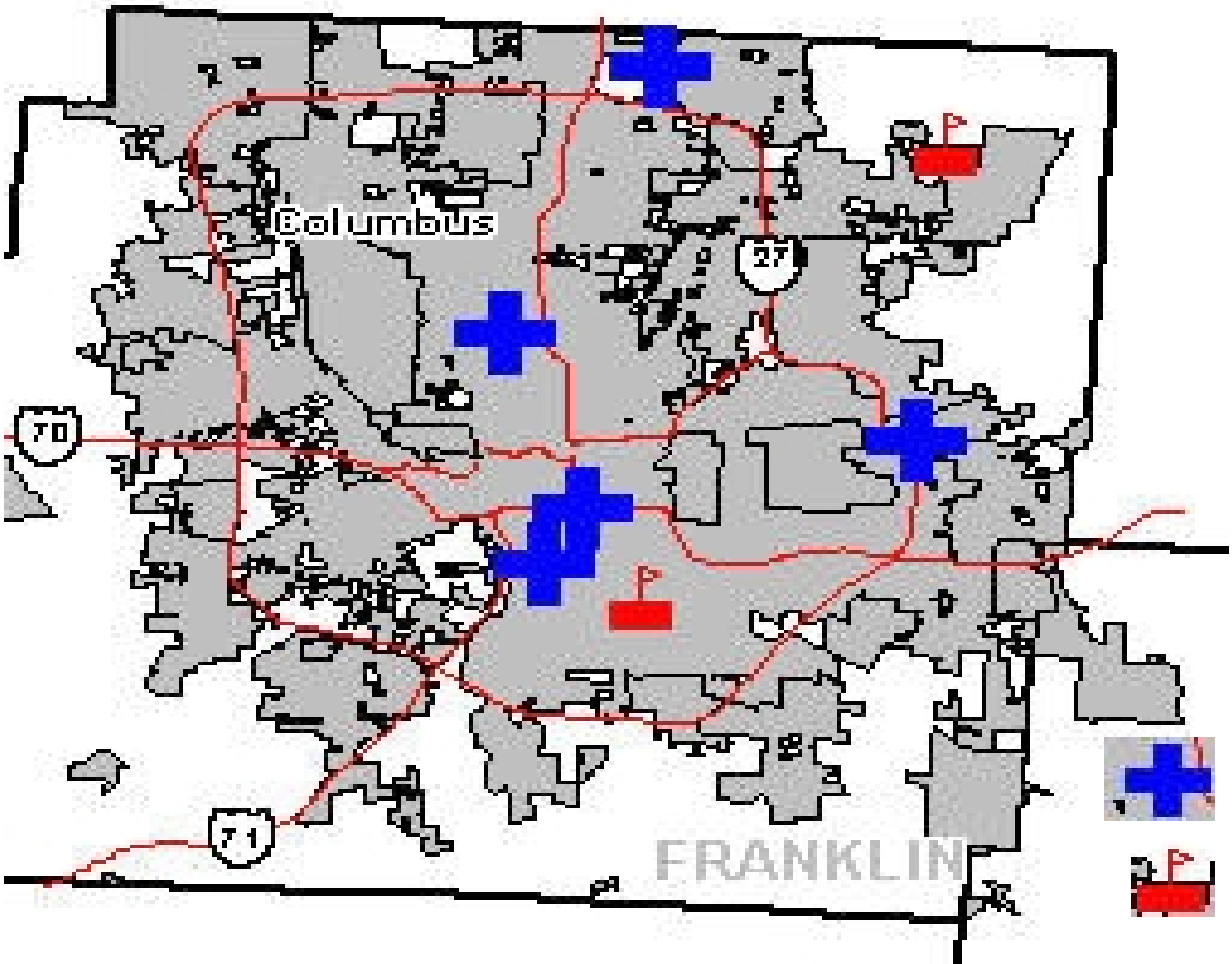
Urban Location

Health Monitoring

- **Peak Flow Meters**

Health Monitoring

Sentinel Sites



Hospital

School

Ambient Monitoring

- $PM_{2.5}$ Continuous
- $PM_{2.5}$ -Filter
- Weather
- Ozone

Personal Monitoring

- **Filter Samples**
  - **7 hr day –5 days per week**

OVMs –Air Toxics

Personal,
Outdoor, Indoor

Analysis of Trace Elements

Energy Dispersive X-ray Fluorescence

Elements : Si, P, S, Cl, K, Ca, Ti, Co, Ni, V, Cr, Mn, Fe, Cu, Zn, As and Cd

Ion chromatography

Anions: F-, Cl-, NO_3 -, SO_4^{-2}, PO_4^{-3}

Cations: Li^+, Na^+ , NH_4^+, K^+, Mg^{+2}, Ca^{+2}

Analysis

- **Water Soluble Ions**
- **Metals**

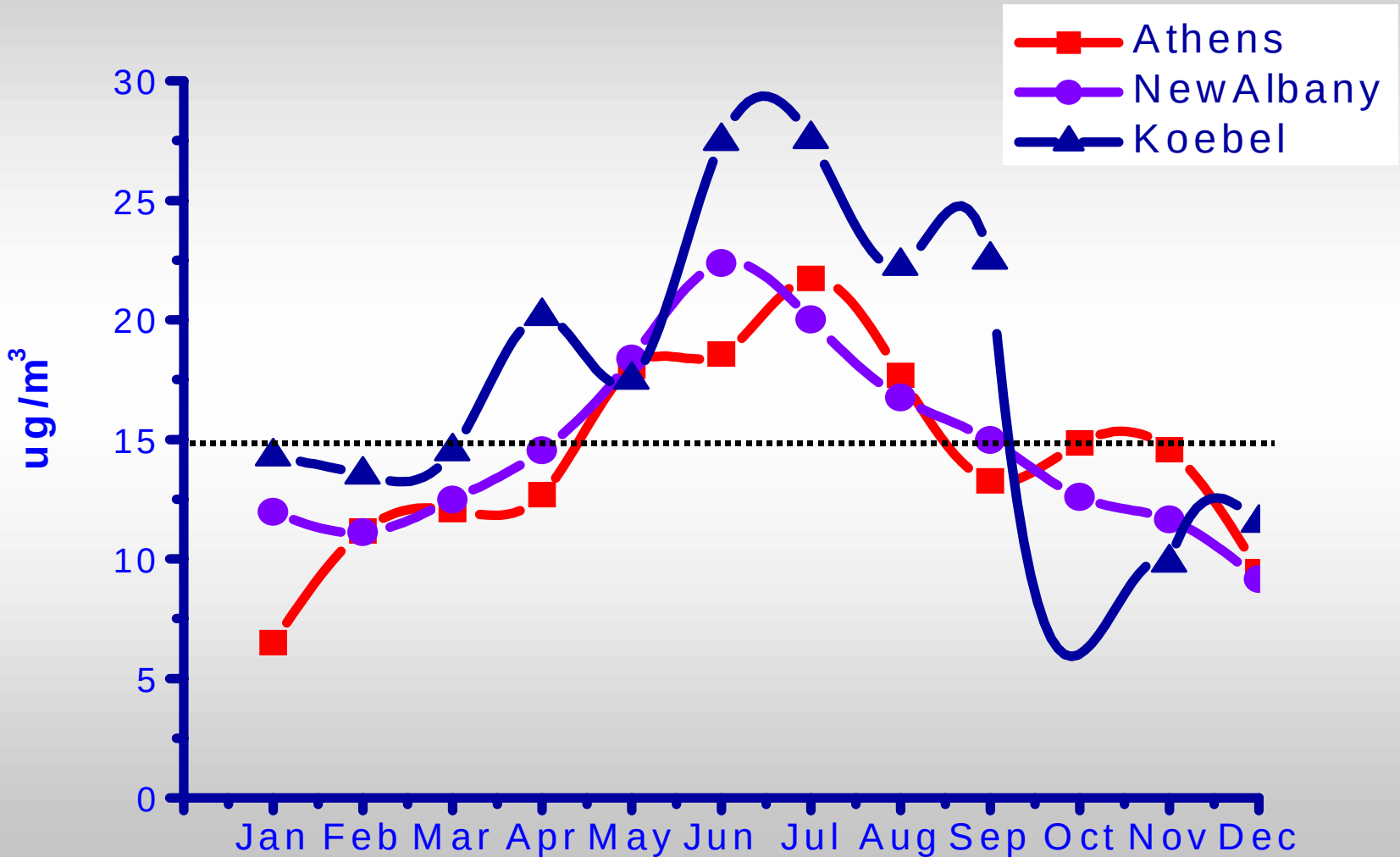
Seasonal Trend of Ambient $PM_{2.5}$

- $PM_{2.5}$ concentrations show clear seasonal changes at all three sites, indicating the trend of ***higher $PM_{2.5}$*** concentrations ***during the summer*** months.

- ***Higher ambient $PM_{2.5}$*** concentrations were identified ***at the urban site***---- Koebel, which was influenced by local sources.

- Data from 1999 and 2000 suggest that all three sites will **exceed** the annual standard of 15μg/m^3.

Monthly TEOM $PM_{2.5}$ Concentrations, 1999



Results and discussion
$PM_{2.5}$ and Meteorological Parameters

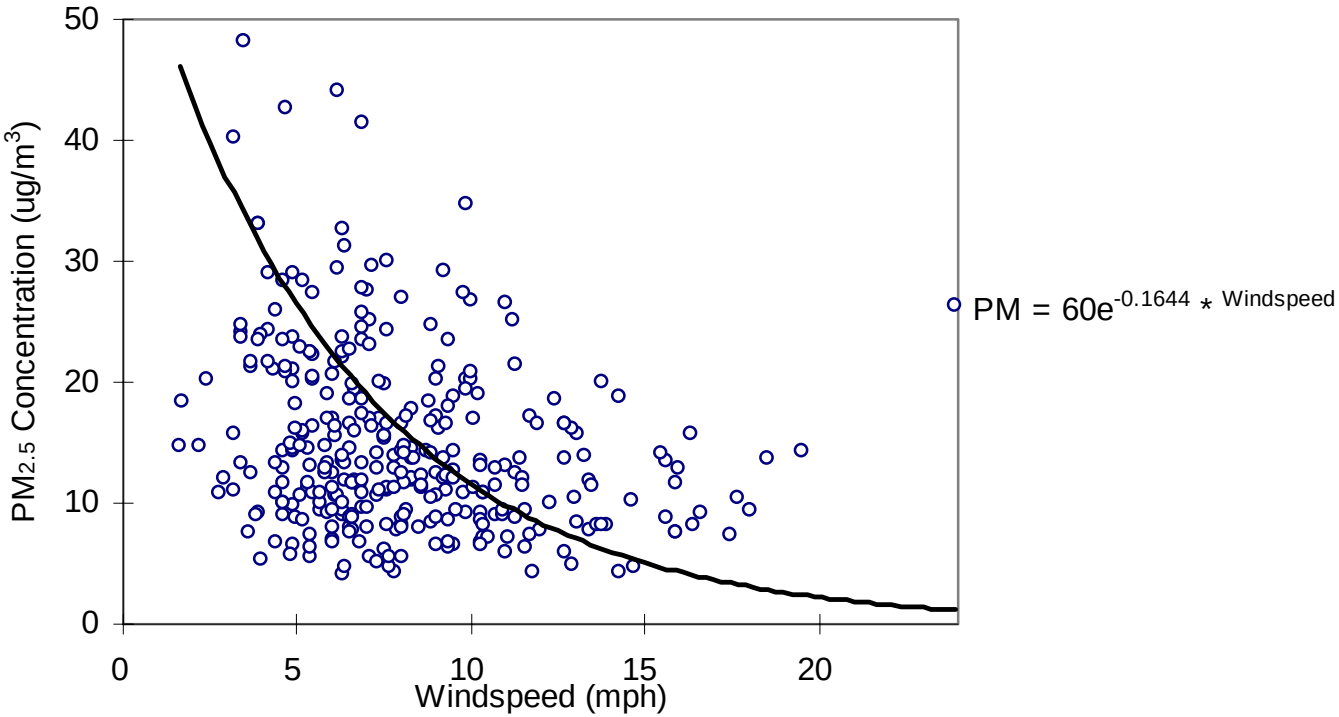
Key Results for Ambient Monitoring

- $PM_{2.5}$ concentrations tended to increase with rising temperatures

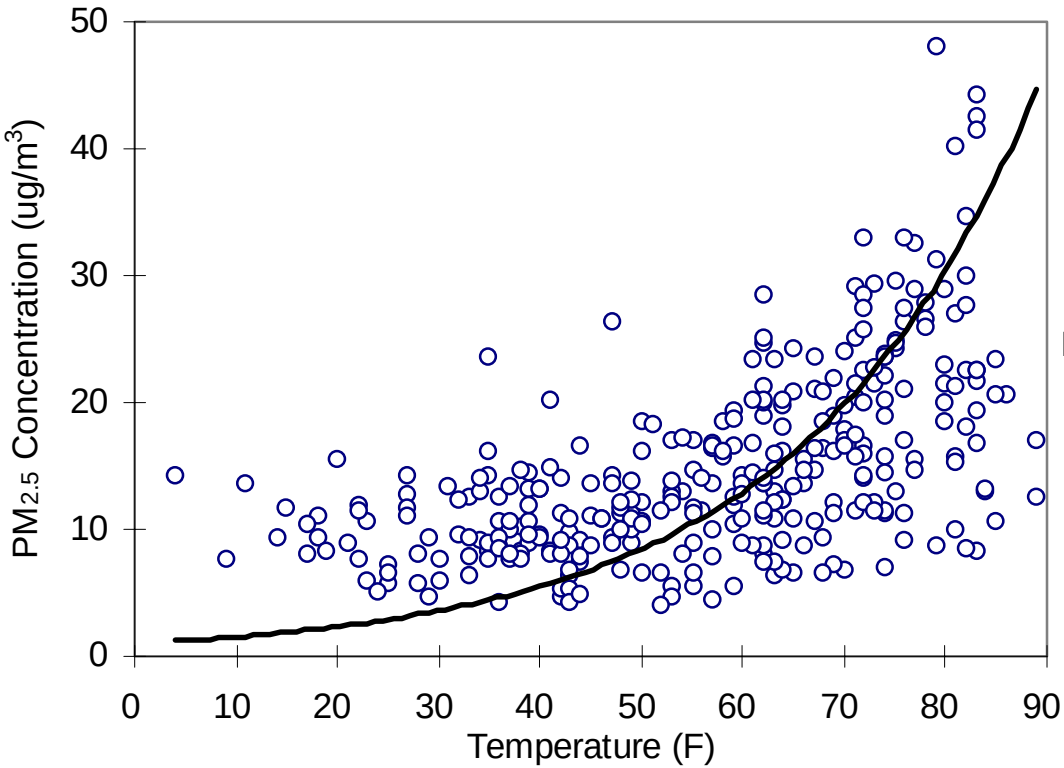
- $PM_{2.5}$ concentrations decreased with increasing wind speed

- $PM_{2.5}$ concentrations in general were highest when the winds were blowing from the south & southeast directions despite the low frequency of occurrence of this particular wind direction.

Relation Between $PM_{2.5}$ & Wind Speed at New Albany

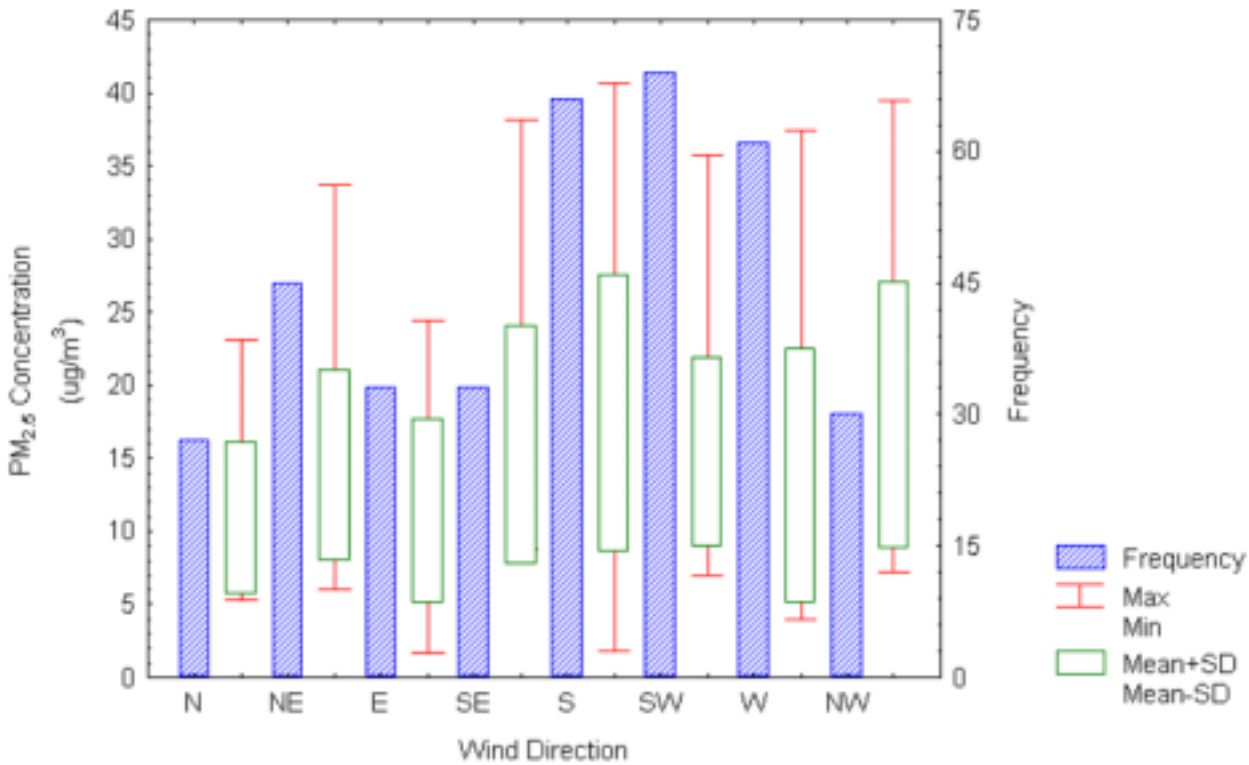


Relation Between $PM_{2.5}$ & Temperature at New Albany



$PM = e^{0.0427 * Temperature}$

Relation between $PM_{2.5}$ & wind direction at Athens (rural)

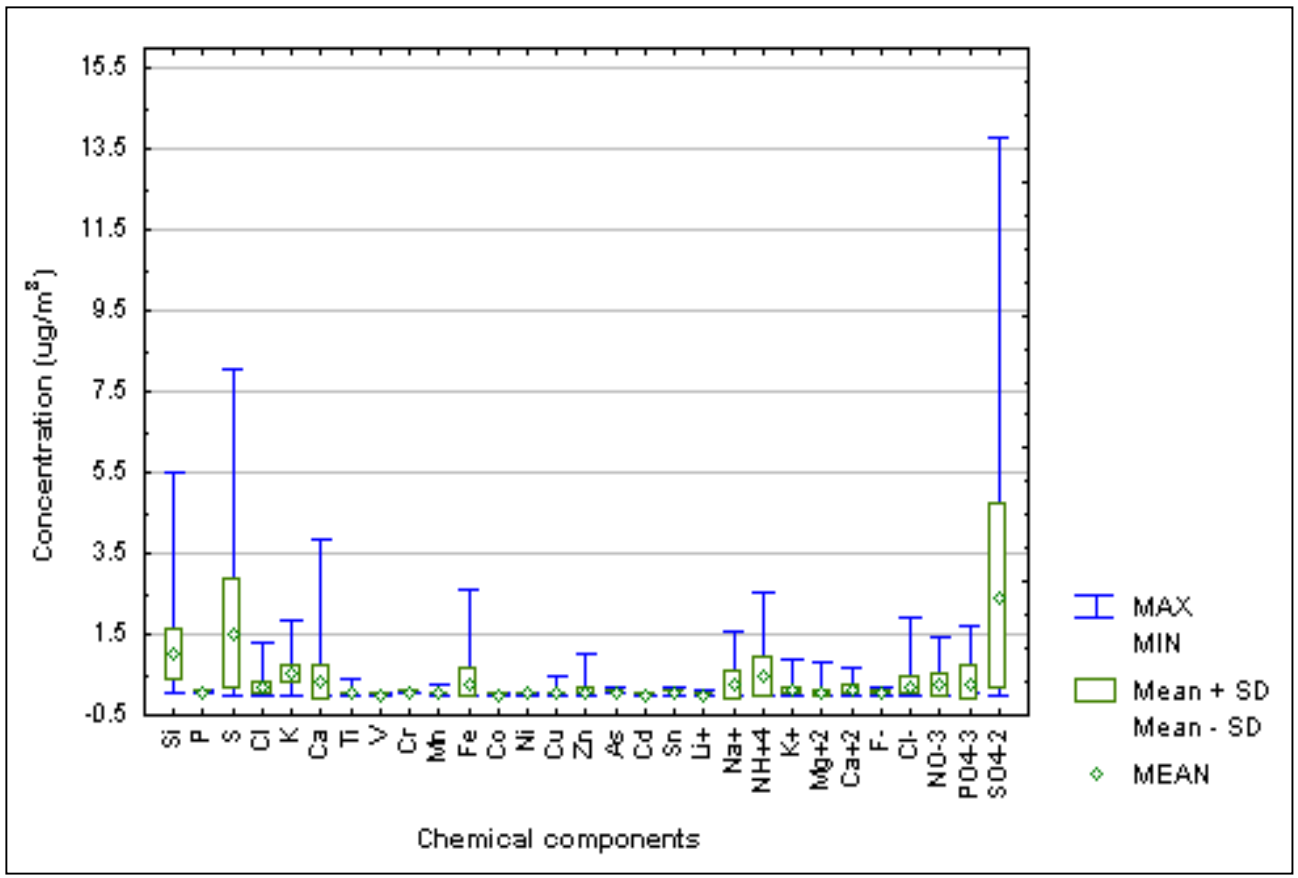


Results and discussion
$PM_{2.5}$ Chemical Species Concentrations

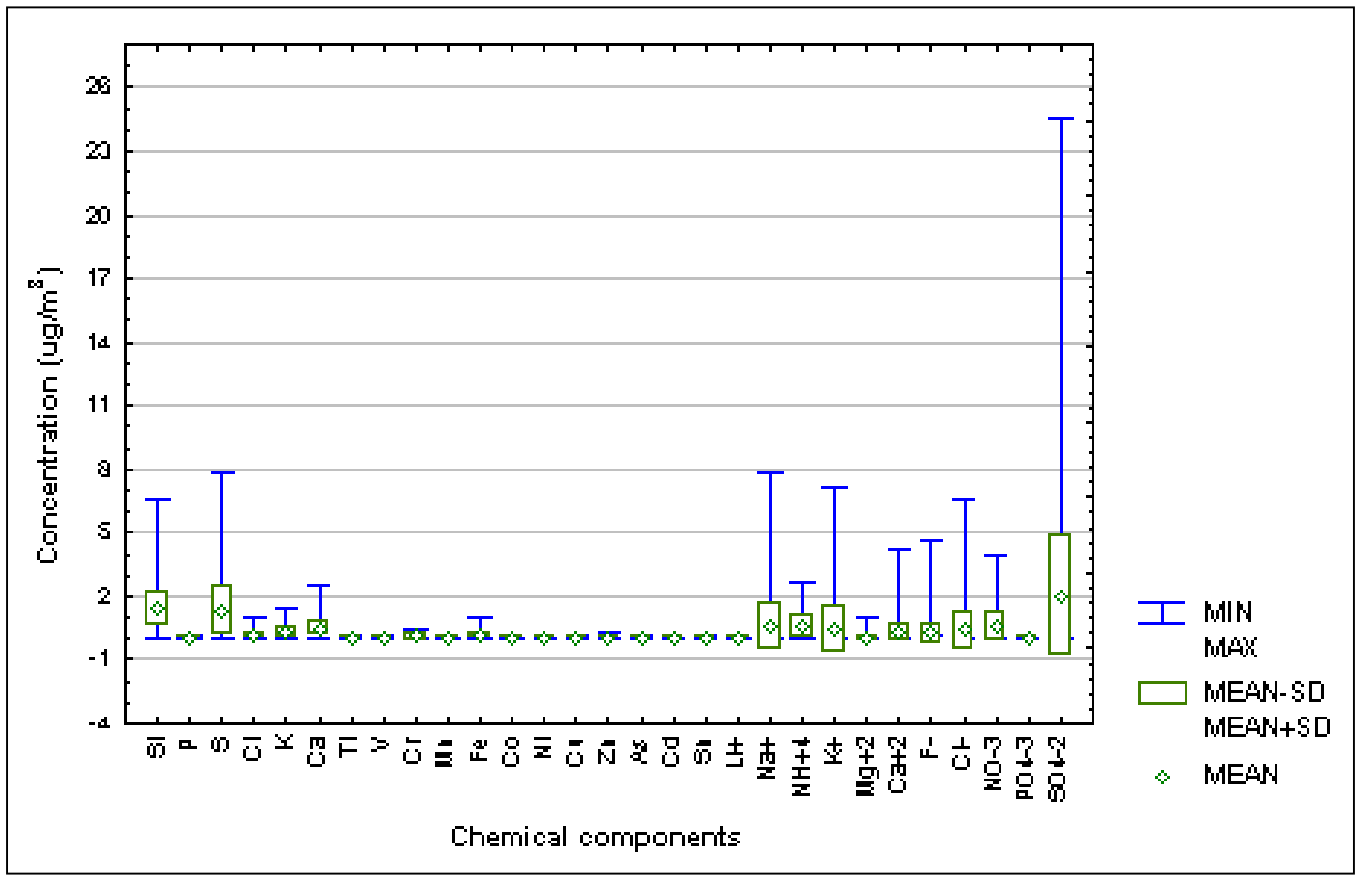
Key Results at Outdoor & Indoor Sites

- Components Identified: Cl^-, NO_3^-, SO_4^{-2}, PO_4^{-3}, Li^+, Na^+, NH_4^+, K^+, Mg^{+2}, Ca^{+2}, Si, P, S, Cl, K, Ca, Ti, V, Cr, Co, Ni, Mn, Fe, Cu, Zn, As, Cd and Sn
- Sulfate major component present in all $PM_{2.5}$ samples.
- Other abundant components included nitrate and ammonium ions and silicon
- Anion and cation average concentrations followed the pattern SO_4^{-2} >NO_3 >PO4 $^{-3}$> Cl^- and Na^+ > NH_4^+ > Ca^{+2} > K^+ > Mg^{+2}
- Heavy metals such as Ti, V, Mn, Fe, Cu and Zn found in all the samples, and iron was the most abundant species

Concentrations of the chemical components present in the samples at Koebel outdoor site (February 1999-August 2000)



Concentrations of the chemical components present in the samples at Koebel indoor site (February 1999-August 2000)

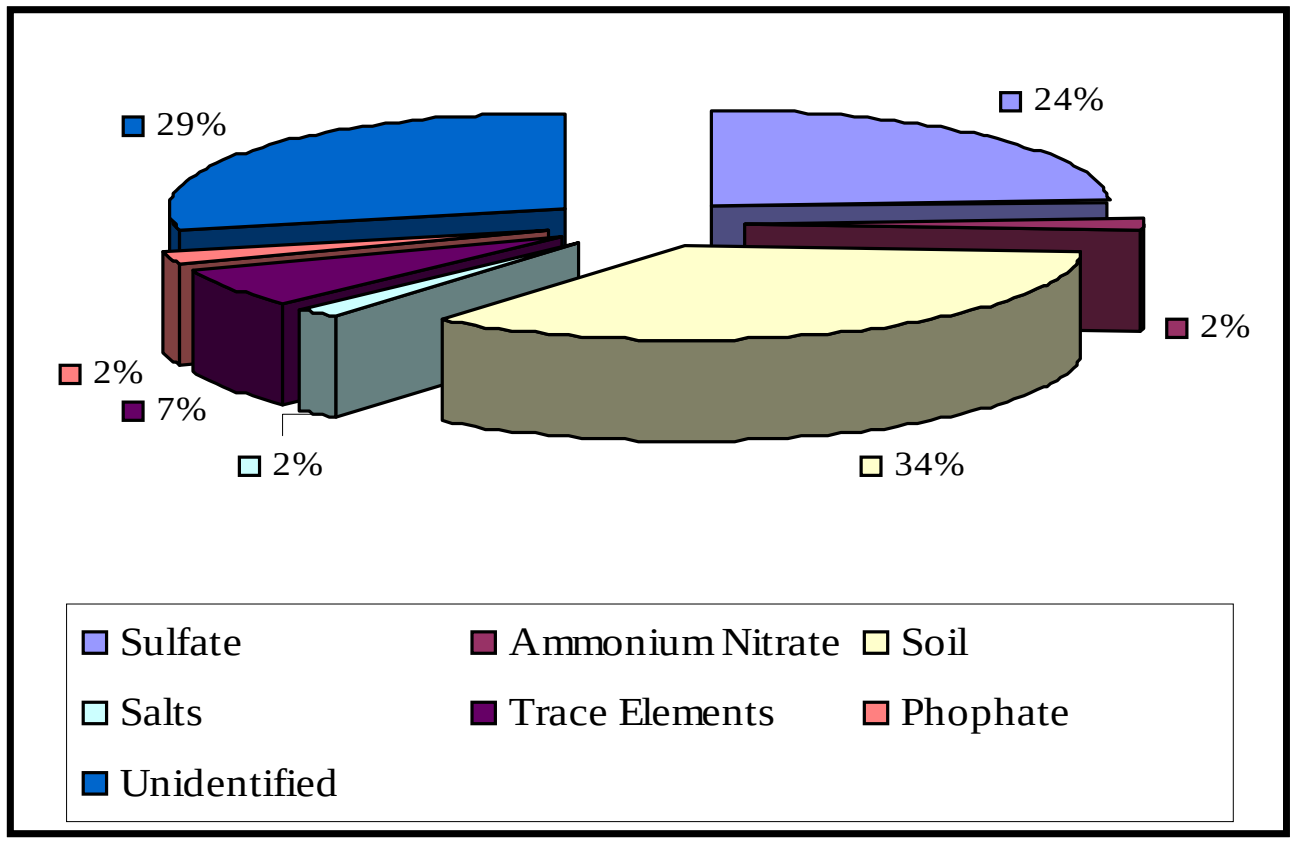


Results and Discussion
Major Chemical Components of $PM_{2.5}$

Key Results for Outdoor Sites

- On an average, 65% of the total particulate ($PM_{2.5}$) mass successfully analysed at the outdoor sites
- Sulfate percentage ranged from 22% to 25% of the total particulate matter mass. Sulfate was highest at the East site
- The percentage range of soil varied from 27% to 34% with Koebel showing the highest percentage
- East rural site showed significantly higher percentage (10%) of phosphates compared to the other two sites

$PM_{2.5}$ components for outdoor ambient air at Koebel (February 1999–August 2000)

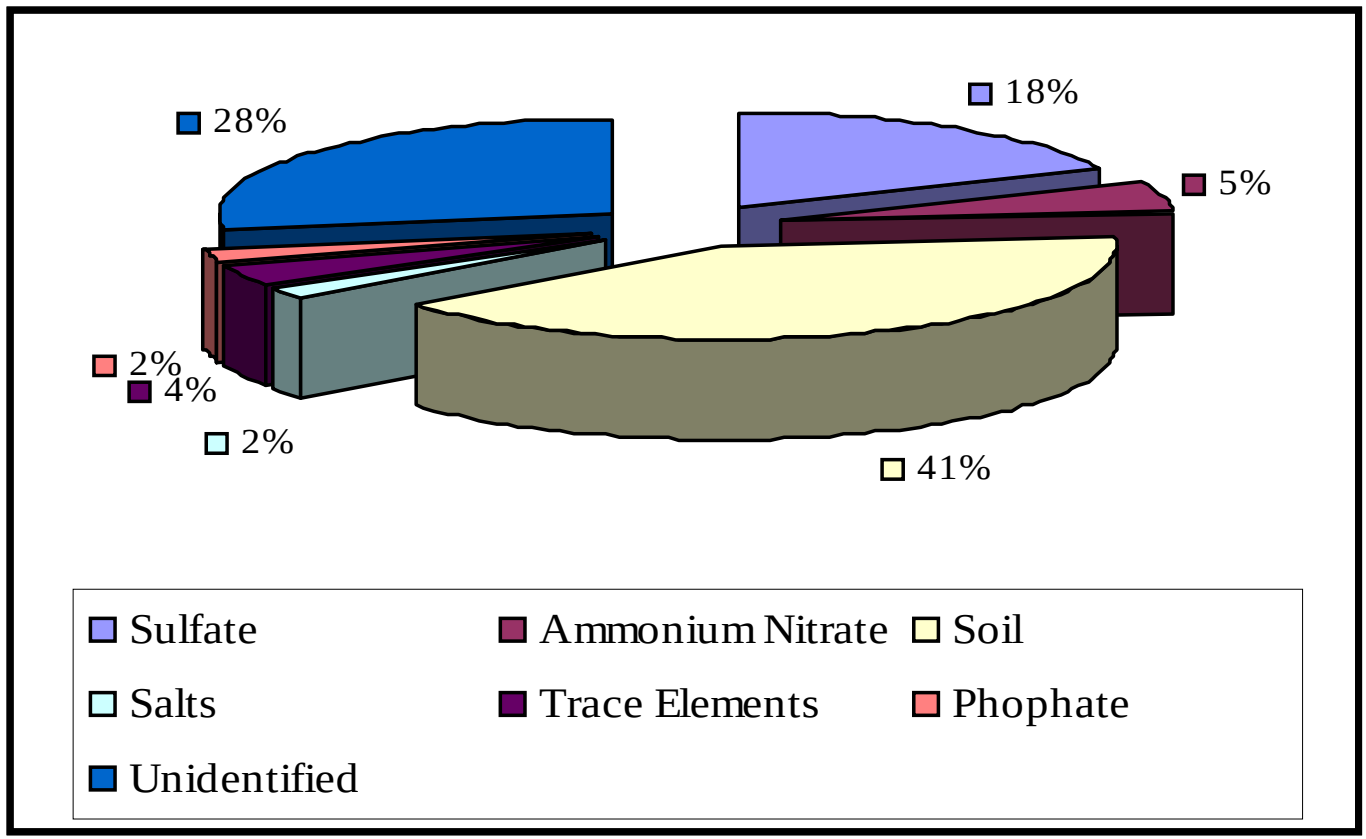


Results and Discussion
Major Chemical Components of $PM_{2.5}$

Key Results at Indoor Sites

- Soil concentration at all indoor sites were higher compared to the outdoor site soil concentrations
- Soil percentage ranged from 36% to 56% at the New Albany and the East indoor site, respectively
- Sulfate concentration was highest at the Koebel site and ranged from 15% to 18 % of the total particulate matter mass
- Little or no phosphate found at the indoor sites

$PM_{2.5}$ Chemical Composition for Koebel Indoor Site (February 1999–August 2000)

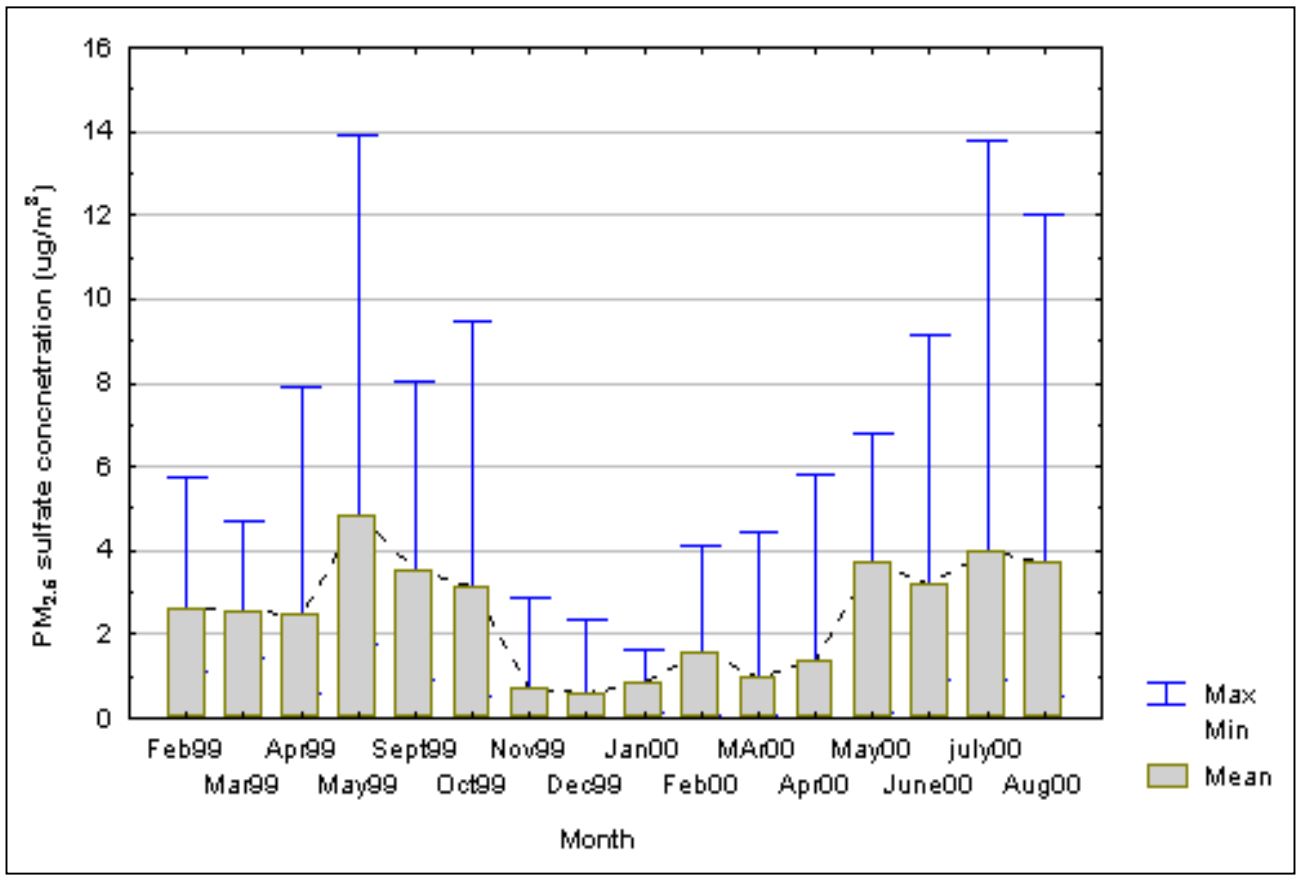


Results and Discussion *Monthly Variations in Sulfate Concentration*

Key Results

- Sulfate ion concentration showed a strong seasonal variations with maximum concentrations observed during the summer months
- Sulfate concentrations increased from winter to summer
- Average $PM_{2.5}$ sulfate concentrations for East, New Albany, and Koebel sites were 2.47, 2.09, and 2.46 $\mu g/m^3$, respectively

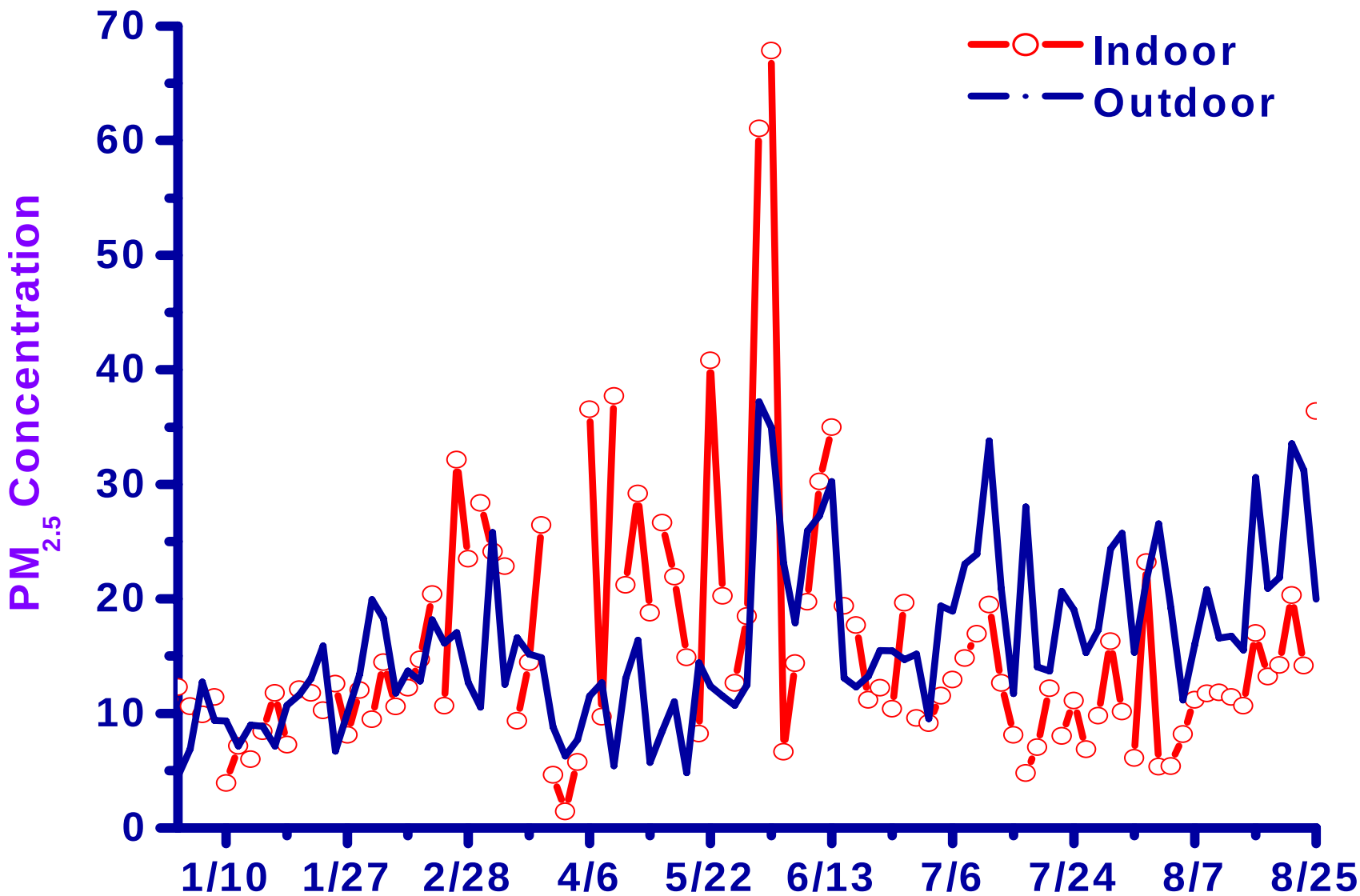
Monthly variations in Sulfate Concentrations for New Albany Outdoor Samples (February 1999-August 2000)



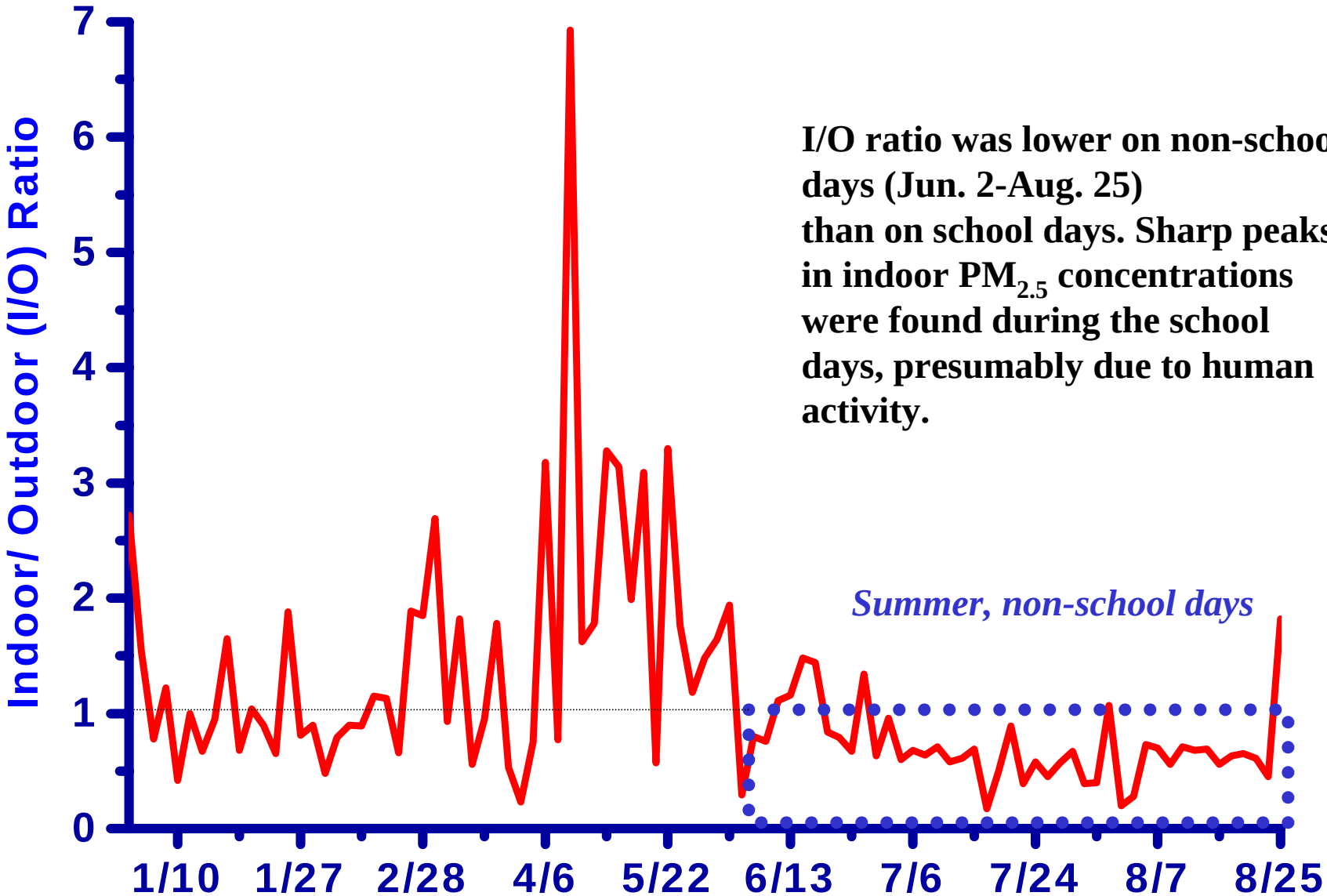
Results and Discussion *Comparison of Indoor and Outdoor Analysis*

- In general, indoor $PM_{2.5}$ concentrations were higher than outdoor levels.

- Human activity in the indoor settings impacts the $PM_{2.5}$ concentration.

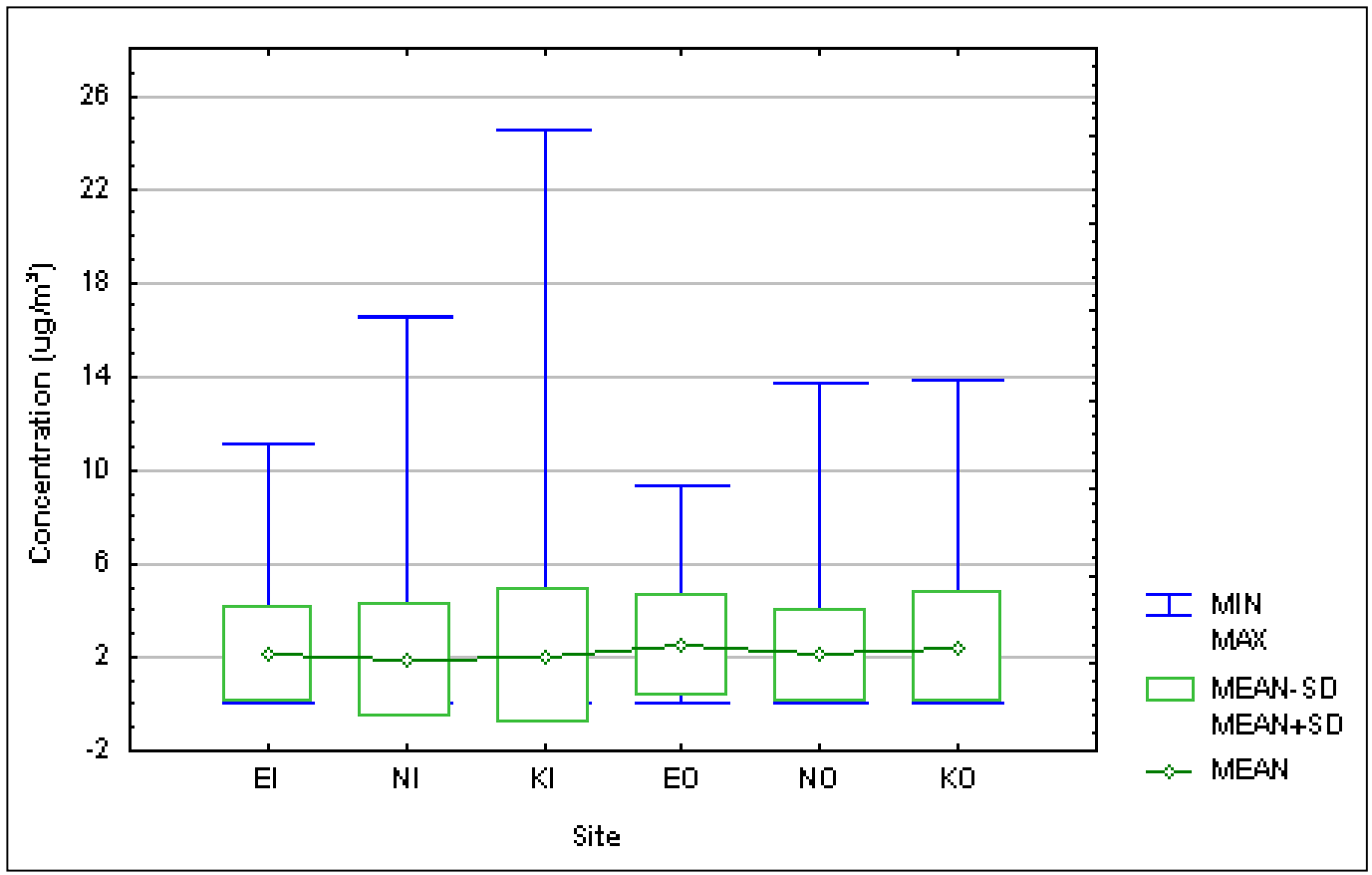

Indoor and Outdoor PM2.5 concentrations at Athens, 2000
PM2.5 Concentration
70
60
50
40
30
20
10
0
1/10
1/27
2/28
4/6
5/22
6/13
7/6
7/24
8/7
8/25
Indoor
Outdoor

I/O ratio at Athens, 2000



I/O ratio was lower on non-school days (Jun. 2-Aug. 25) than on school days. Sharp peaks in indoor $PM_{2.5}$ concentrations were found during the school days, presumably due to human activity.

Sulfate ion distribution in Ohio
(February 1999 – August 2000)



Summary & Conclusions

- On an average, 65% of the total particulate ($PM_{2.5}$) mass was successfully analysed at the indoor and outdoor sites.
- The components determined by the chemical analysis included: F^-, Cl^-, NO_3^-, SO_4^{-2}, PO_4^{-3}, Li^+, Na^+, NH_4^+, K^+, Mg^{+2}, Ca^{+2}, Si, P, S, Cl, K, Ca, Ti, Co, Ni, V, Cr, Mn, Fe, Cu, Zn, As and Cd.
- Sulfate comprised the largest fraction.
- Other abundant components included phosphate, nitrate, ammonium, chloride, sodium, calcium, silicon, and iron.
- Soil concentration (36% - 56%) at the indoor sites were found to be significantly higher compared to the outdoor site soil concentrations

Summary & Conclusions cont.

- Sulfate ion concentration showed strong seasonal variations with maximum concentrations observed during the summer months
- $PM_{2.5}$ concentrations tended to increase with rising temperatures, and decreased with increasing wind speeds.
- $PM_{2.5}$ concentration was highest when the winds were blowing from the south and the southeast direction at the three sites.

Summary & Conclusions cont.

- In general, indoor $PM_{2.5}$ concentrations were higher than outdoor levels
- Human activities in the indoor settings affected the monitored levels.

Acknowledgements

Ohio EPA
Ohio Air Quality Development Authority