Source Contributions of Dust to Atmospheric PM in Middle East

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Overview

- Dust Storms and Non-Dust Storm Events

- Types of Dust of Concern

- Fresh Dust and Aged Dust

- Example Studies from the Middle East

  - Baghdad, Iraq

  - Amman, Zarqa, and Aqaba - Jordan

  - Tehran, Iran

  - Lahore, Pakistan

- Concluding Remarks

What Dust Exposures are of Concern?

- Large Regional Dust Storms
  - Extreme Events
- Extreme Haze Events
  - Can have large dust contributions
- Contribution to Annual Average Exposure
  - Fine Particulate Matter ($PM_{2.5}$)
  - Course Particulate Matter (PM_{10}-$PM_{2.5}$)
- Micro-Environmental Exposure Near Source
  - Concern for Urban Population Exposures

Defining Dust

- Source Region
  - Local Dust
  - Transported Dust
- Source Type
  - Natural Dust
  - Anthropogenic Dust
- Contamination Level
  - Geological Dust
 - Aged Dust
  - Contaminated Dust
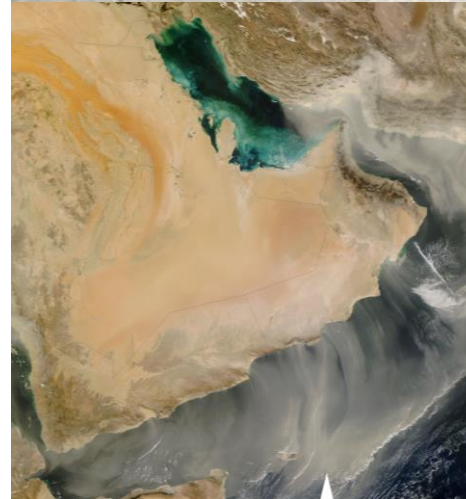
Types of Dust

- Natural Geological Dust

- Atmospheric Aged Natural Geological Dust
  - Results from mixing with anthropogenic pollution

- Resuspension of Geological Material that is Contaminated with Anthropogenic Sources

- Anthropogenic Sources that are Comprised of Geological Materials
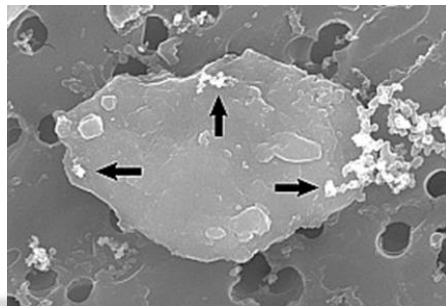
# Annual Average Comparison of PM2.5 Crustal Elements in 11 Middle East Cities (Abdeen et al., 2014)
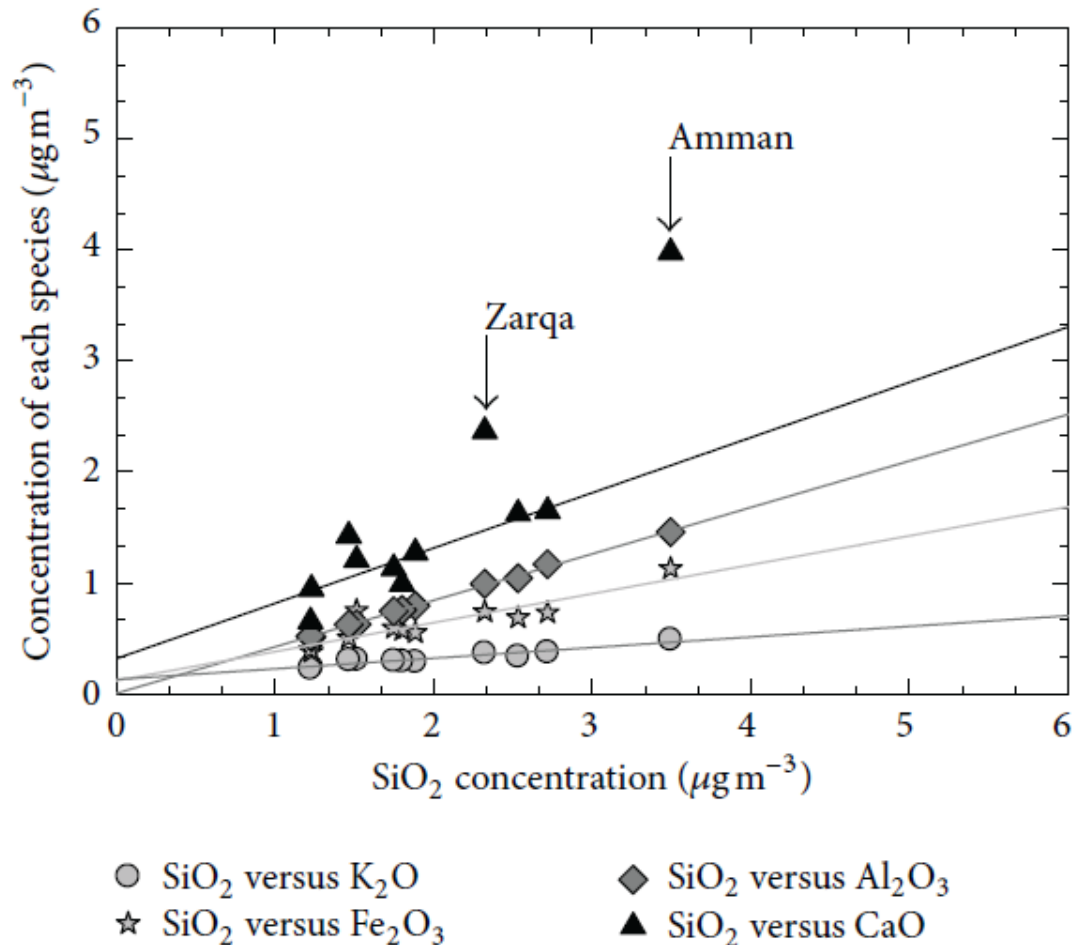
Quantifying Dust Contributions

- Dust mass is quantified by measuring crustal elements and using a "Dust Model"
  - Si, Al, Ca, Fe, Ti, Mn, and sometimes K
- Not the only contributor to Coarse PM
  - Should not define Dust as Coarse PM
- Biological active components of dust increase with atmospheric aging and mixing with anthropogenic pollution
- Need to be consistent in the definition of dust in health studies and source apportionment

The water-soluble fraction of carbon, sulfur, and crustal elements in Asian aerosols and Asian soils

R.M. Duvall[a], B.J. Majestic[b], M.M. Shafer[b], P.Y. Chuang[c], B.R.T. Simoneit[d], J.J. Schauer[a,b,*]
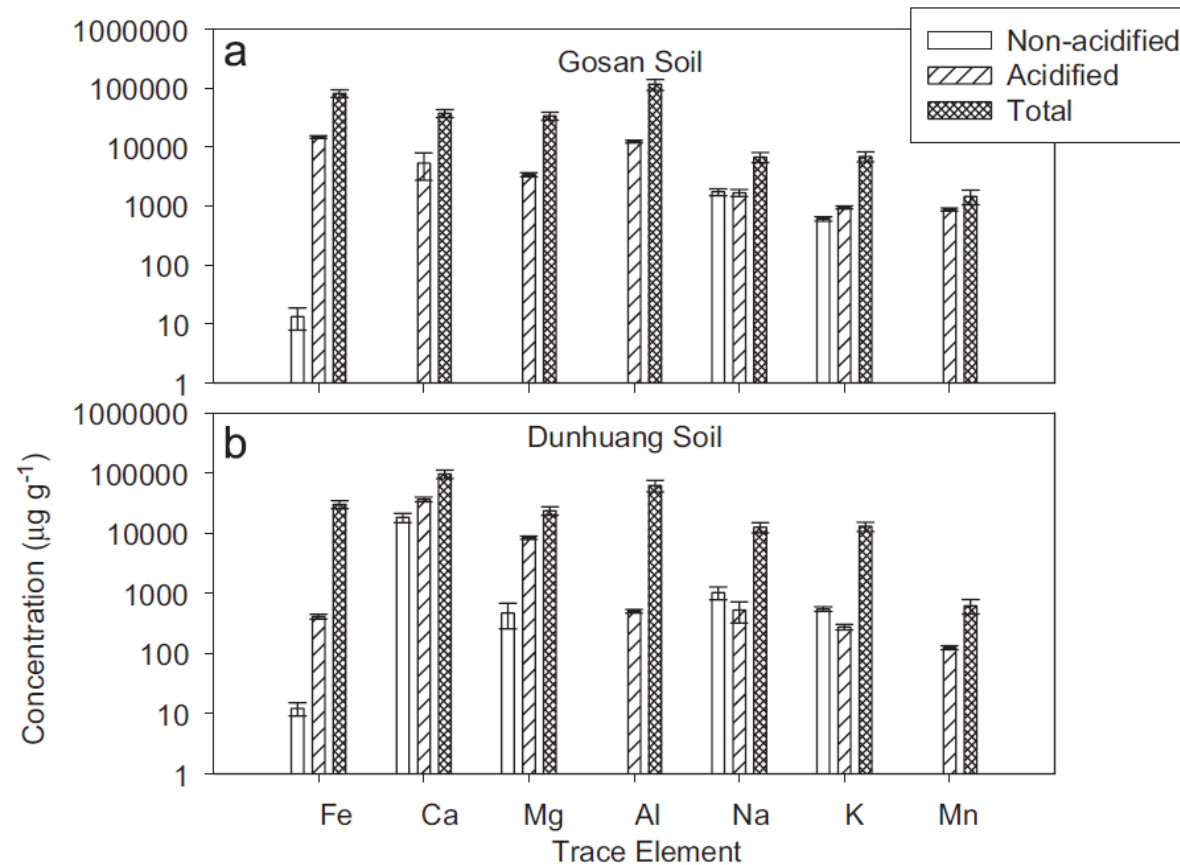
Dust Aging in Atmospheric Transport

- Acidification from nitric acid
  - Converts carbonates to nitrates and leads to more bioavailable metals
- Coagulation with anthropogenic particles
  - Attached biological active compounds to dust
- Adsorption of organic compounds on dust
  - Pesticides and other persistent organic compounds (POPs)
- Redox Cycling of metals like Fe that can change biologic activity

Example Studies

- Baghdad - Iraq
  - $PM_{2.5}$ every 6th day for a year - 2012
- Amman, Zarqa, and Aqaba - Jordan
  - $PM_{2.5}$ every 6th day for a year - 2007
- Tehran - Iran
  - $PM_{2.5}$ every 6th day for a year - 2013
- Lahore - Pakistan
  - $PM_{2.5}$ and PM_{10} every 6th day for a year - 2007

Baghdad

Second largest city in Middle East
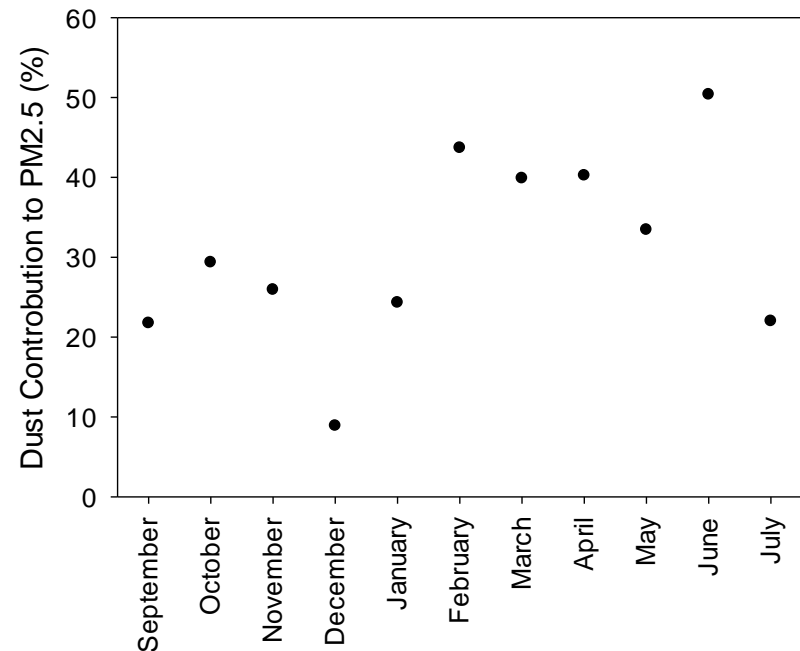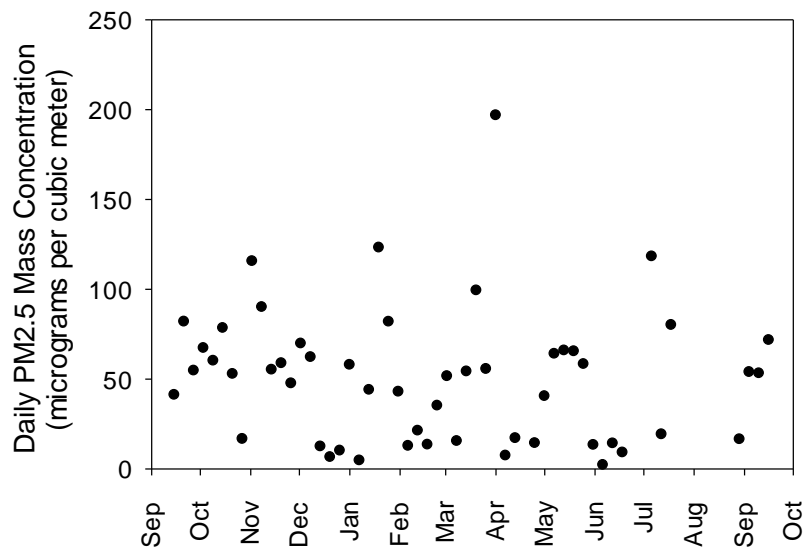Population:
7,216,040 in 2011

Hamad et al., AE 2015

Baghdad Visibility Data

a) Daily Visibility (Miles); 15 Sep-2012 through 16 Sep-2013
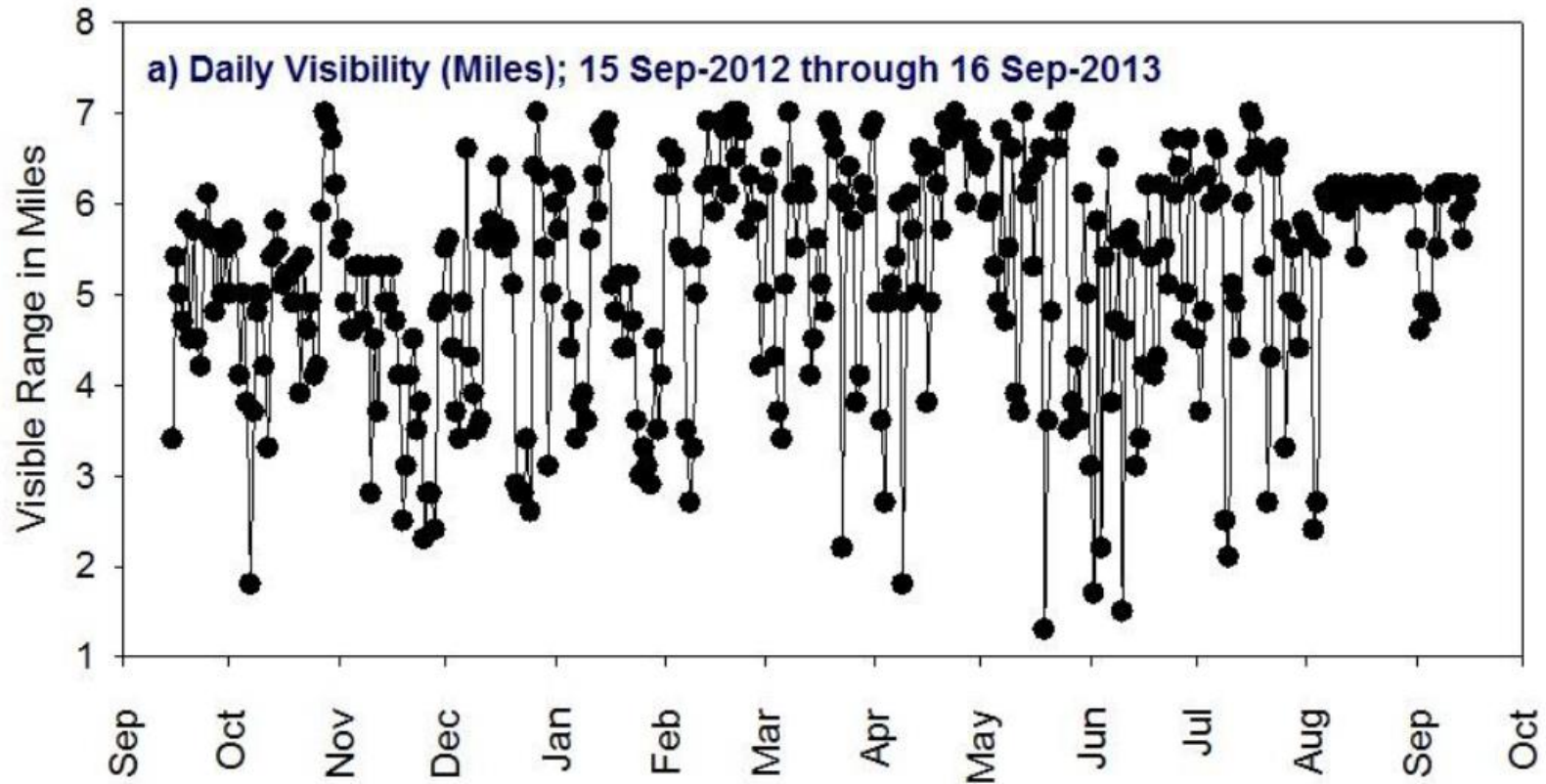
PM2.5 Mass and Contribution of Dust to PM2.5 – Baghdad 2012-2013

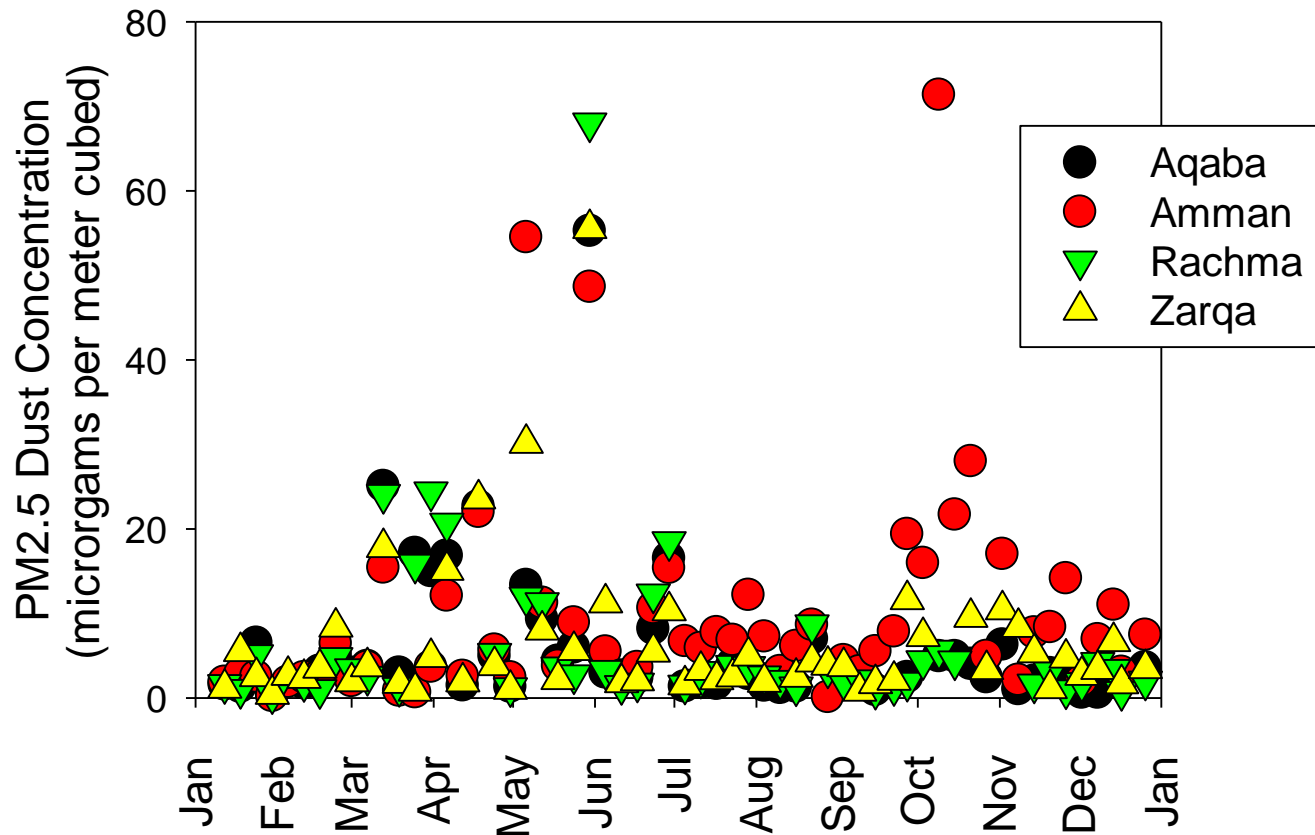## PM2.5 Mass – 2007 Average

PM2.5 Dust – 2007 Average
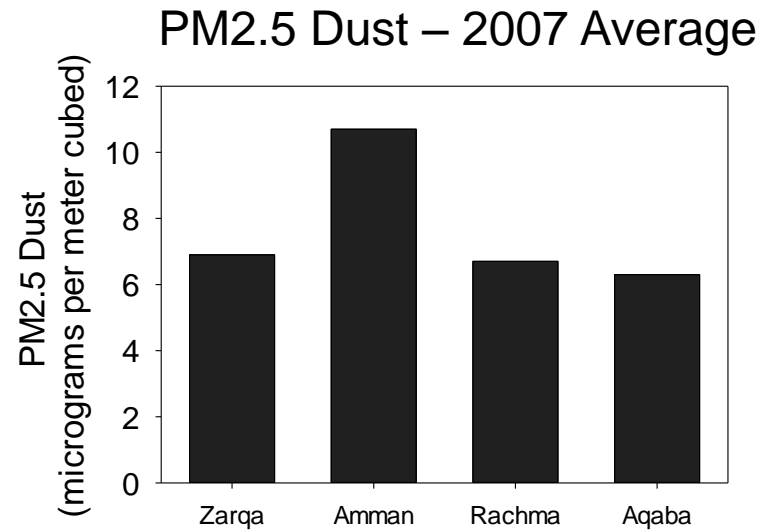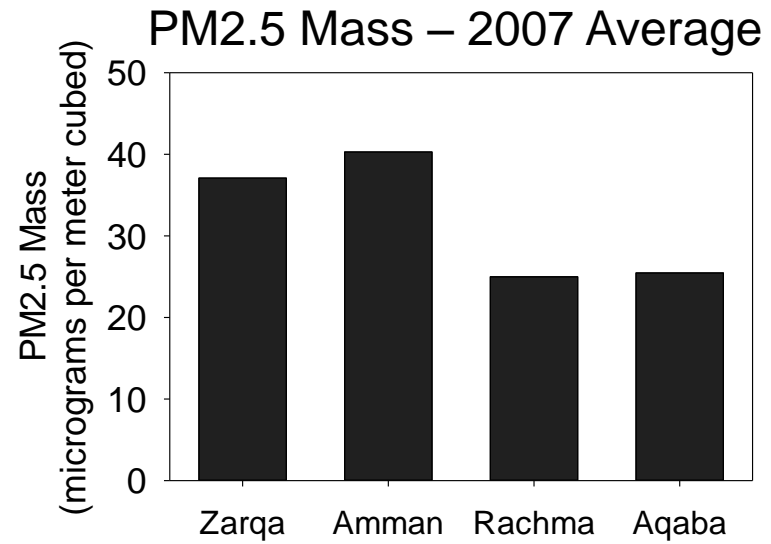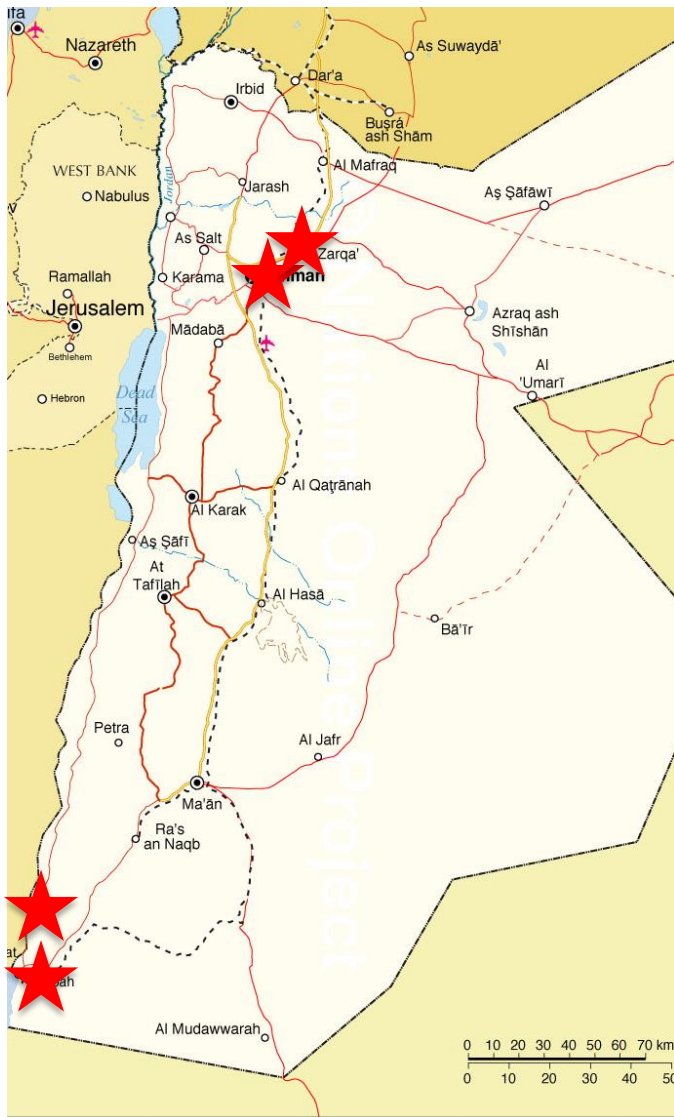
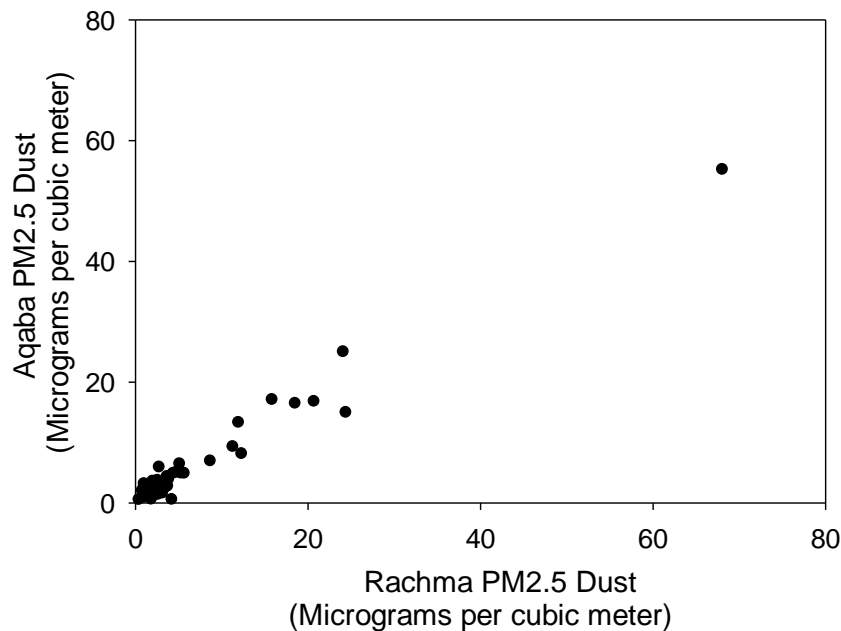# PM2.5 Dust at Four Sites in Jordan
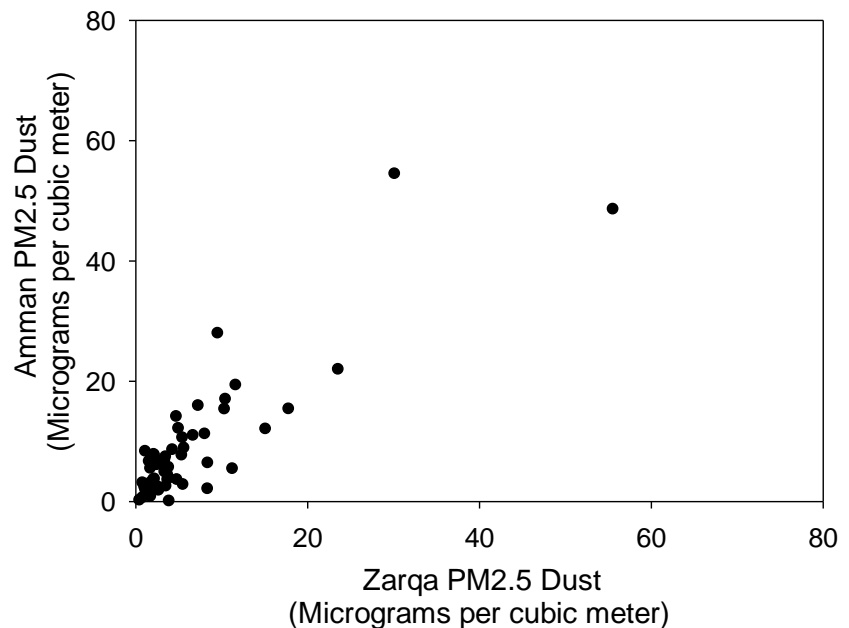## 24-hour Average – 2007
(Abdeen et al. 2014)

Comparison of Daily PM2.5 Dust Across Sites in Jordan - 2007


Aqaba and Rachma

Amman and Zarqa

Tehran Air Pollution Study

- Collaboration
  - Sharif University
  - Tehran Air Pollution Control District
  - University of Wisconsin-Madison
- PM2.5 Samples Collected Every 6th day from Feb 2014 to Feb 2015
  - Detailed Chemical Analysis
  - Biological Assays
  - Source Apportionment
- Starting Phase II in 2016

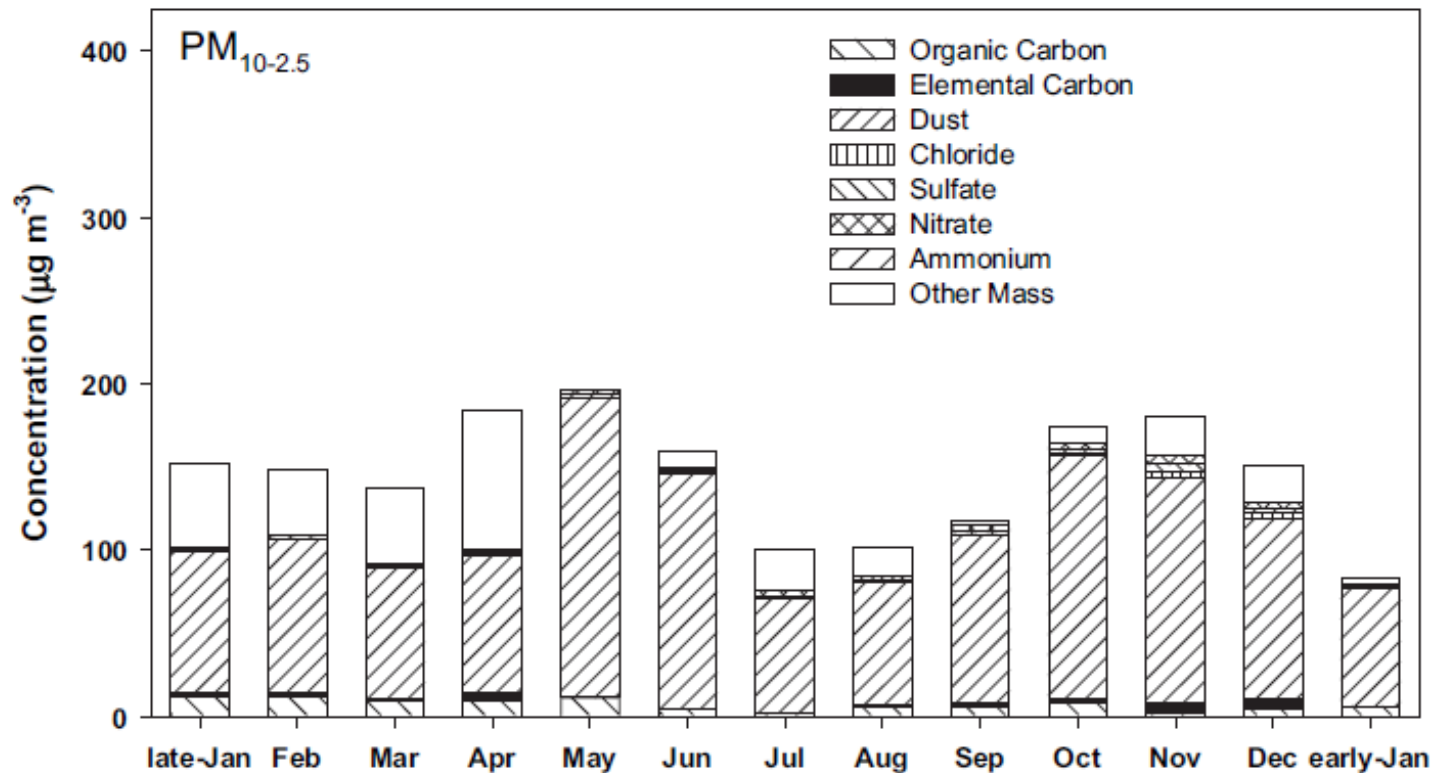# Dust Contribution to Daily Average PM2.5 - Tehran - 2014
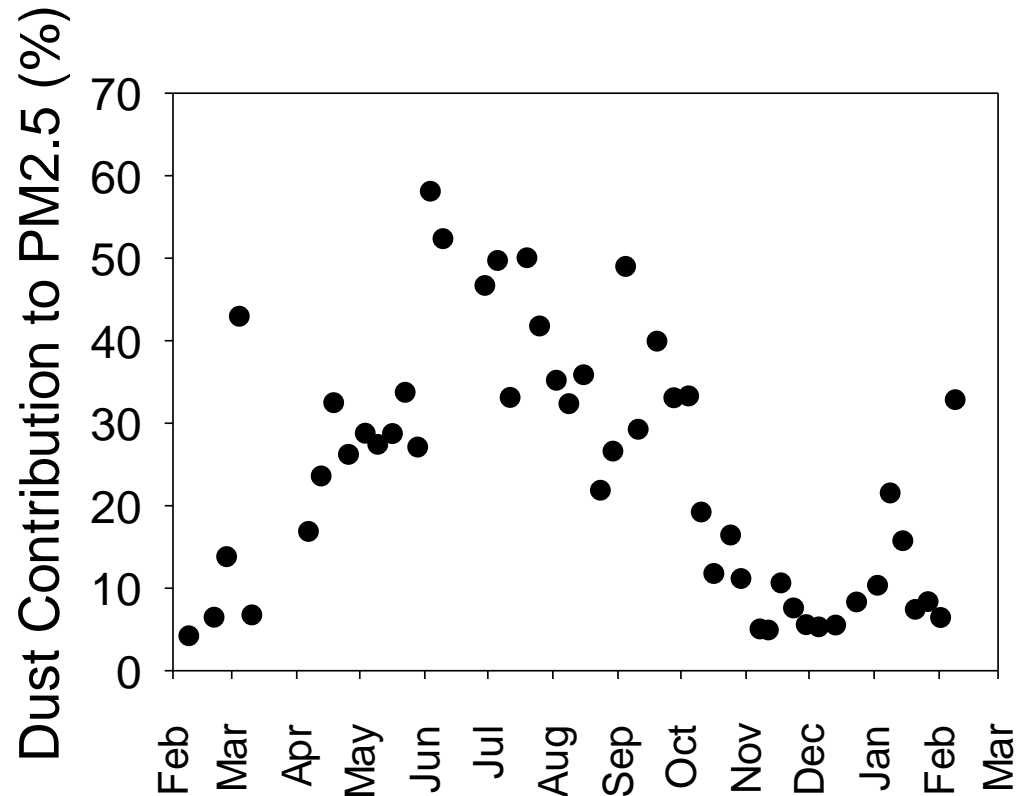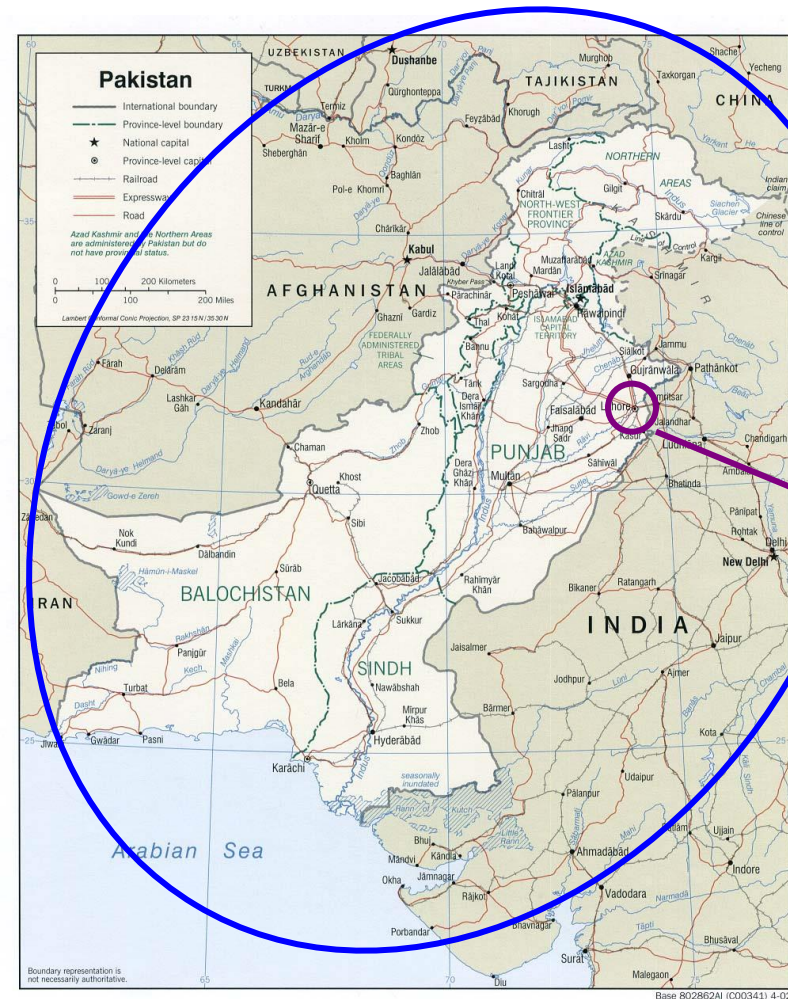
Lahore, Pakistan
- The second biggest city of Pakistan
- Location: 31°34' N, 74°20' E
- Sub-tropical and semi-arid region
- Population: 10,000,000
- Annual temperature: 17.8-30.8 C
   Precipitation: 628.7 mm
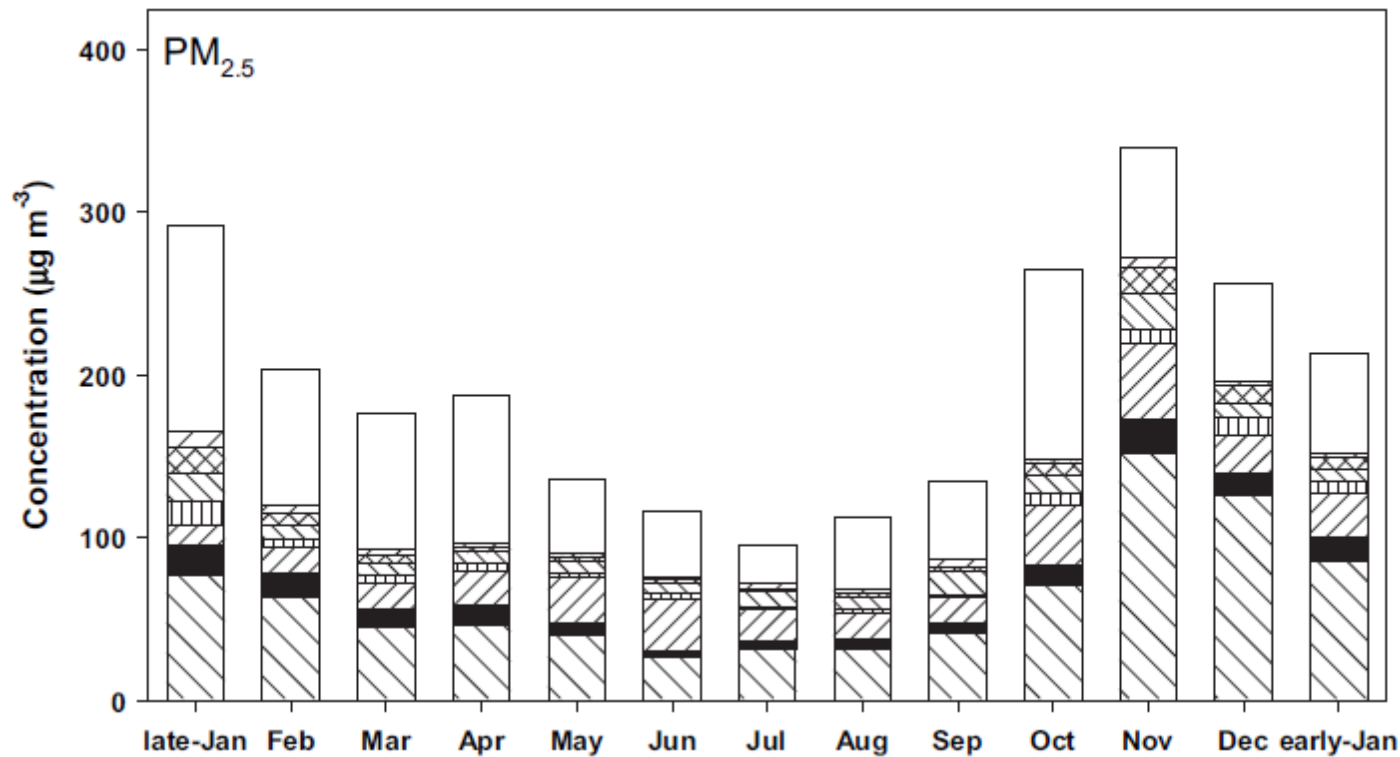
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UNIVERSITY OF WISCONSIN−MADISON

Dust Contribution to Course PM Lahore, Pakistan - 2007

Dust Contribution to PM10 Lahore, Pakistan - 2007
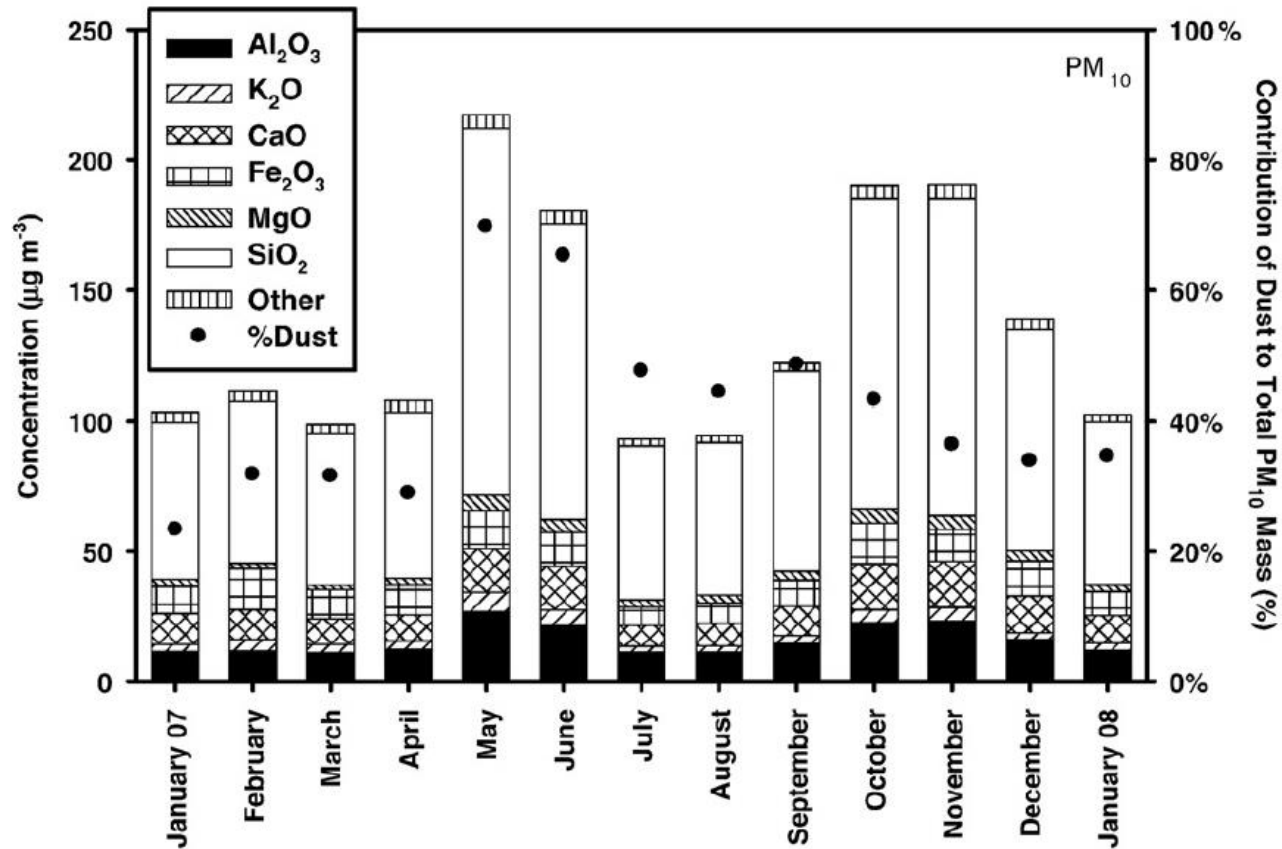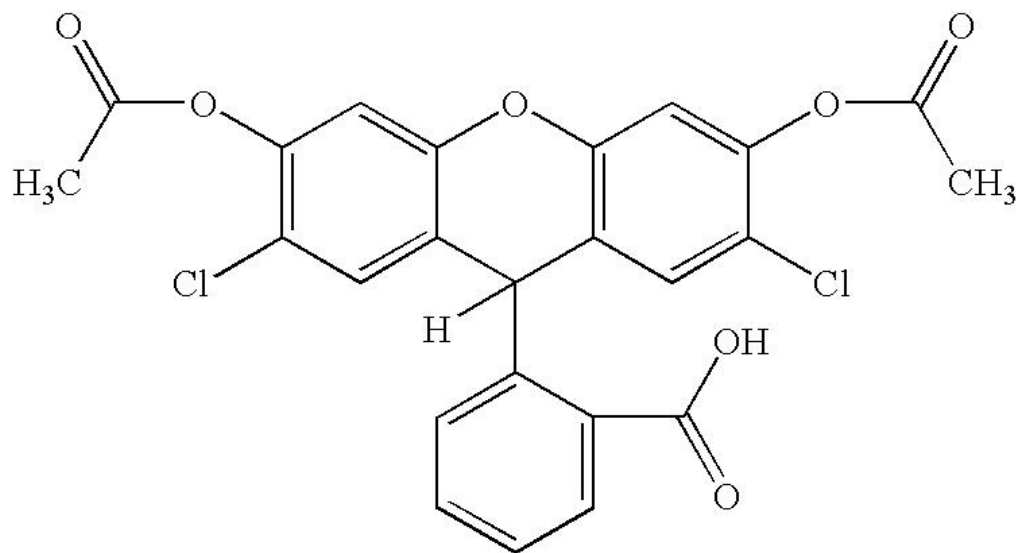
# Dust Contribution to PM2.5 Lahore, Pakistan - 2007

A Macrophage-Based Method for the Assessment of the Reactive Oxygen Species (ROS) Activity of Atmospheric Particulate Matter (PM) and Application to Routine (Daily-24 hr) Aerosol Monitoring Studies

Amy Prasch Landreman, Martin Shafer, Jocelyn Hemming, Michael Hannigan, and James Schauer

2′7′-dichlorodihydrofluorescein diacetate (DCFH-DA, Sigma)

College of Engineering
UNIVERSITY OF WISCONSIN–MADISON
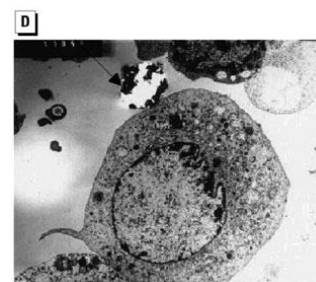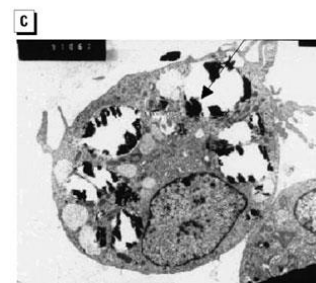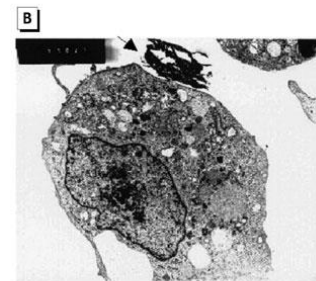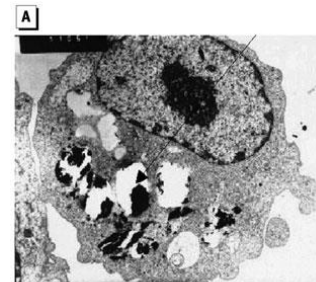
Reactive oxygen species activity and chemical speciation of size-fractionated atmospheric particulate matter from Lahore, Pakistan: an important role for transition metals†

Martin M. Shafer,[*a] Dawn A. Perkins,[b] Dagmara S. Antkiewicz,[b] Elizabeth A. Stone,[a] Tauseef A. Quraishi[c] and James J. Schauer[a]
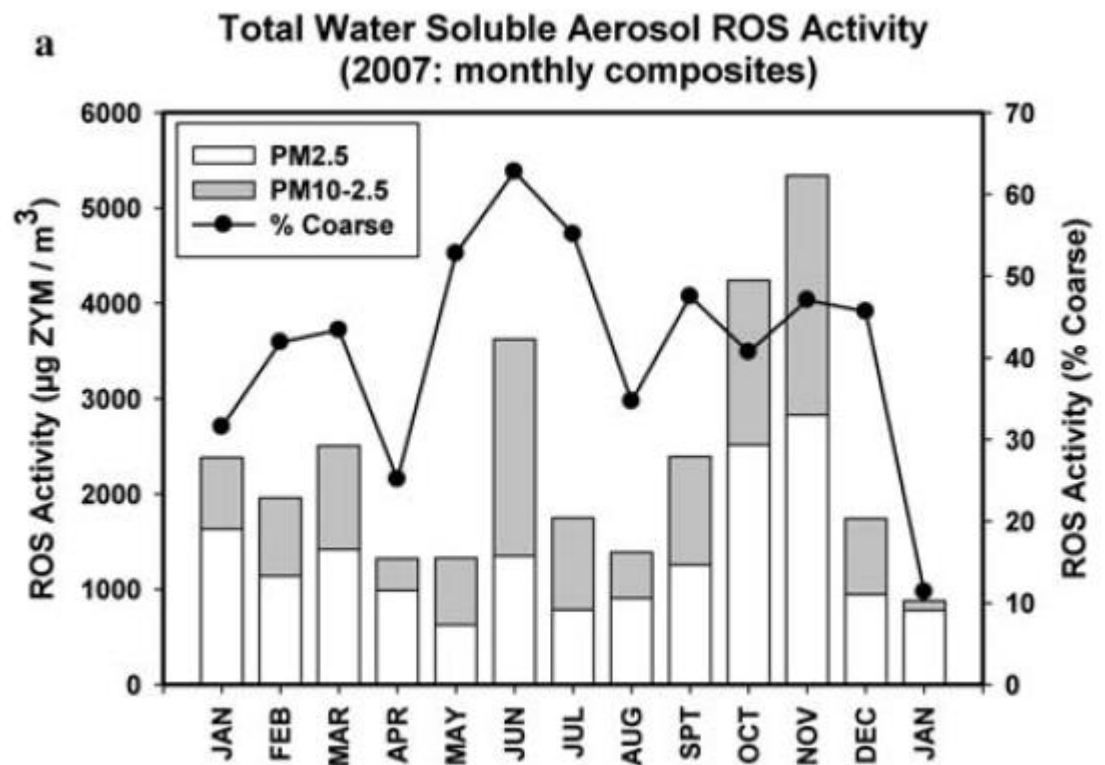
Conclusions

- Dust is an important contributor to PM in the Middle East during dust events and non-dust events
- Sources and the chemistry of dust is diverse and need to be considered for health impacts
  - Atmospheric Aging of Dust
  - Contaminated Dust
  - Anthropogenic Dust
- Tools exist to quantify dust in routine monitoring networks and should be incorporated into PM monitoring networks in the MENA Region
- Great need for Data in North Africa