Sources of the fine particulate matter (PM2.5) in the West Midlands using multiple receptor modelling approaches

Deepchandra Srivastava, Supattarachai Saksakulkrai, W. Joe F. Acton, Daniel J. Rooney, James Hall, Siqi Hou, Mark Wolstencroft, Suzanne Bartington, Roy M. Harrison, Zongbo Shi, William J. Bloss

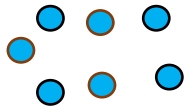
WM-AIR@CONTACTS.BHAM.AC.UK

@WMAIR_UOB

WM-AIR.ORG.UK

Natural Environment Research Council

Introduction to Air Quality



Particulate matter ($PM_{2.5}$)

WHO guidelines (5 µg m^{-3} annual mean) are exceeded in most urban areas in England

Exposure to air pollution:
UK: 28,000-36,000 premature deaths
West Midlands: with 2070 deaths, 2070 asthma diagnoses, 770 CHD diagnoses, 170 lung cancers and 650 strokes

The total cost of $PM_{2.5}$ exposures to national health services and social care:

- £1.5 billion by 2025
- £5.1billion by 2035.

Air quality action plan

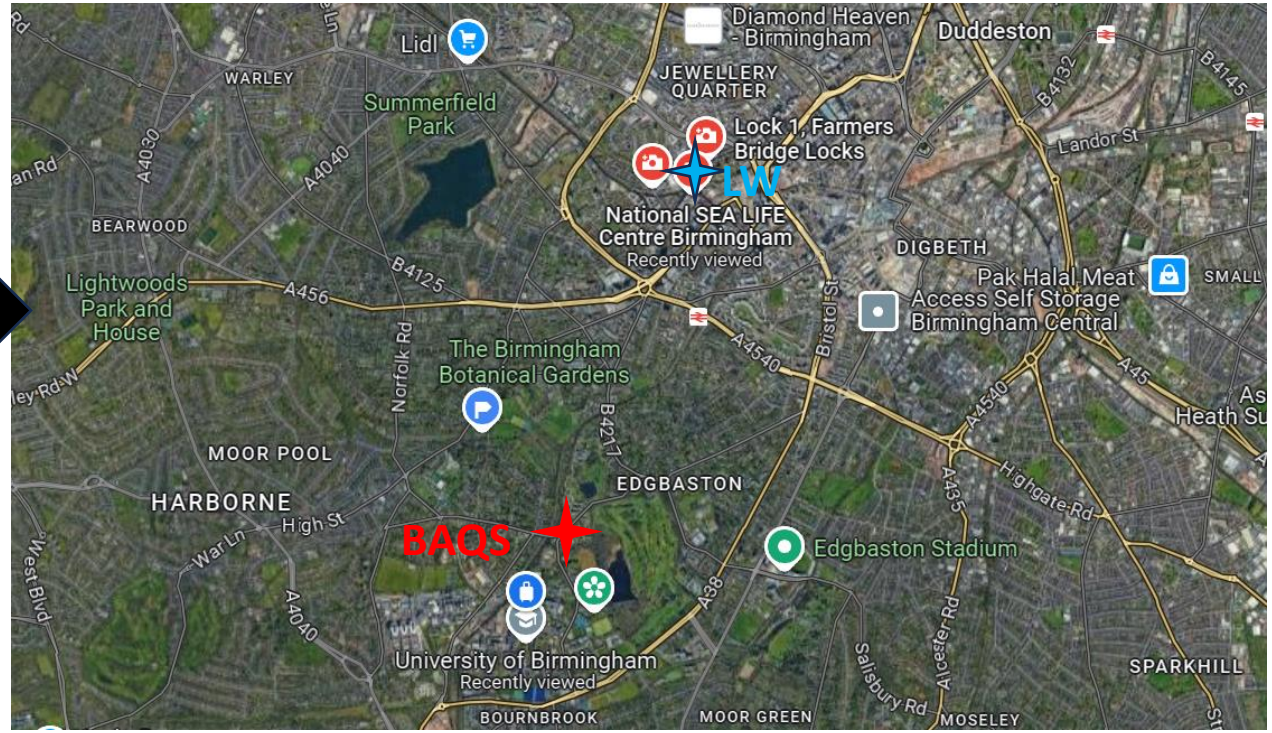
Focus on the reduction of nitrogen dioxide (NO_2) (traffic, via CAZ)

Quantitative source apportionment/ last one was done 15 years ago

"This study presents the results obtained from the receptor modelling applied to a filter-derived dataset collected in the West Midlands"

Monitoring Sites in Birmingham

- Birmingham Air Quality Supersite ("BAQS") and Ladywood ("LW")
- Urban background sites



Sampling and Analysis details

- 24-hour Filter
- Sampling period at BAQS: Jan 2021-Feb 2022
- Sampling period at LW: Jan 2021-Dec 2021

High Volume Sampler

- Filter were analysed for Organic carbon (OC), Elemental Carbon (EC), Ions, Metals and Organic compounds.

Filter sample

OC/EC

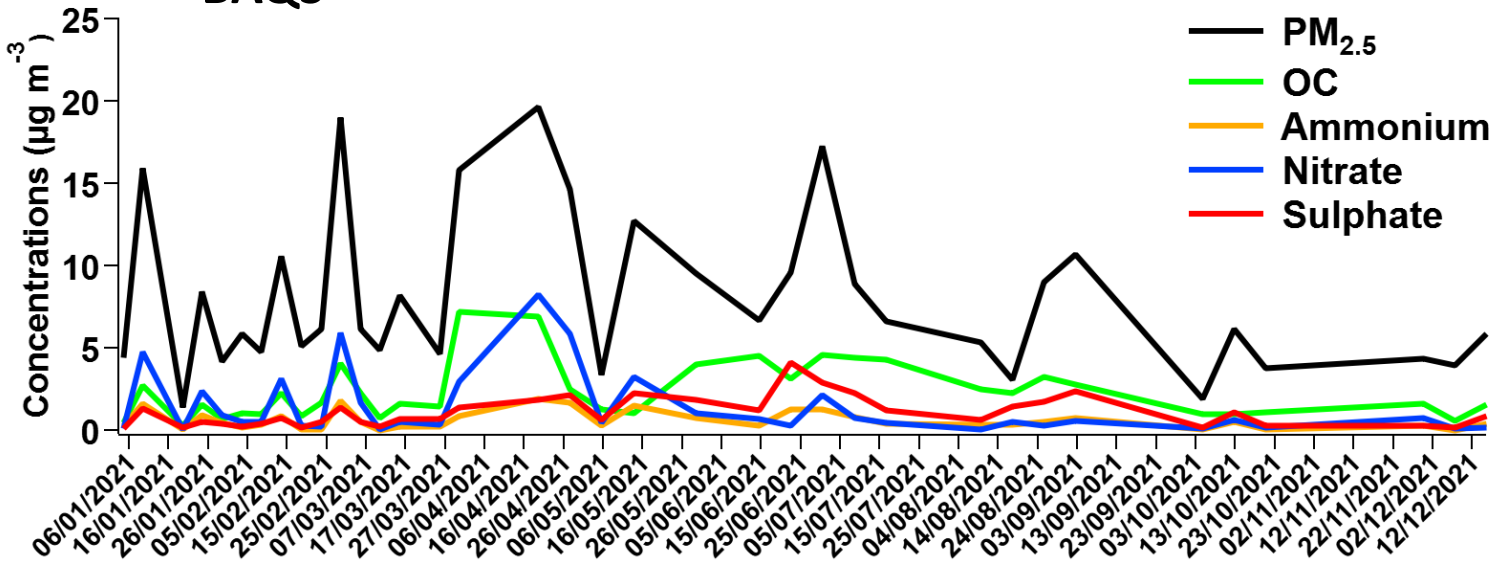
Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, NO_3^{-}, SO_4^{2-}, NH_4^{+}, Cl^{-}

Fe, Al, Ti, Sb, Ni, V, Cu, Zn, Cr, Pb, Ce, Cd, Co, Mn

Organics-levolglucosan (LG), mannoson (MN), Glactosan (GA),……..

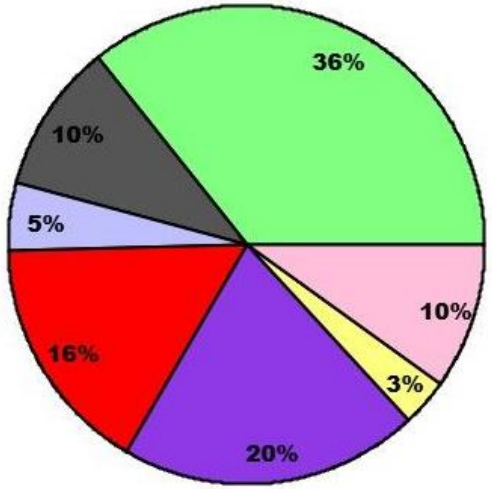
$PM_{2.5}$ chemical composition/trends

BAQS

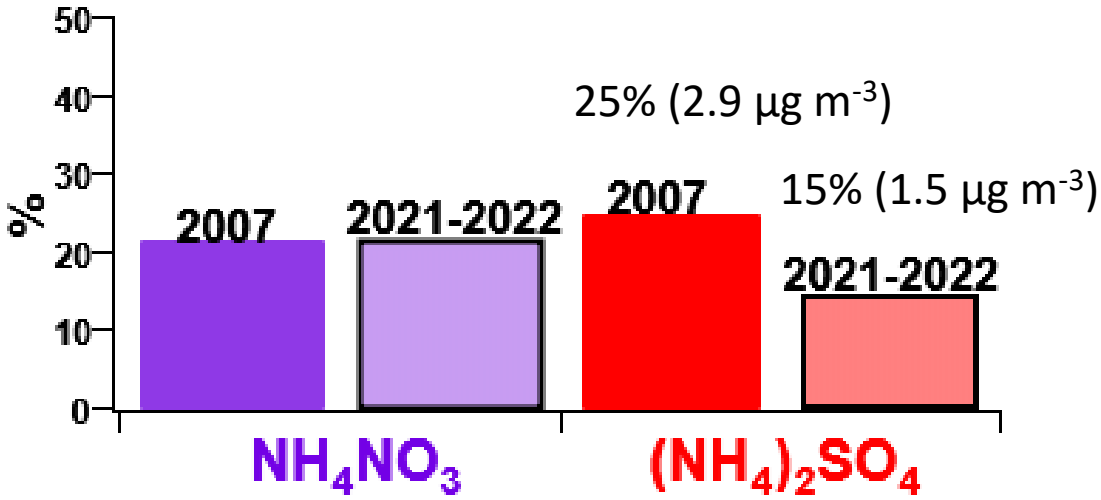


Average annual $PM_{2.5}$ =8.1 µg m^{-3}
WHO limit= 5 µg m^{-3}
England→10 µg m^{-3} is to be achieved by 2040
London: 10.1 µg m^{-3}

Chemical mass closure



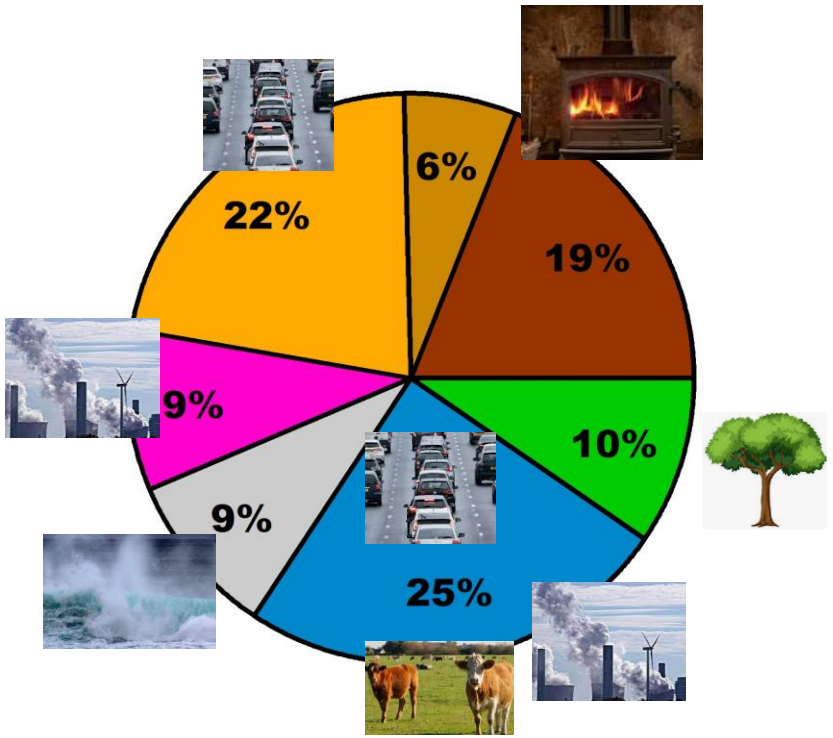
OM
EC
Sea salt
$(NH_4)_2SO_4$
NH_4NO_3
Calcium salts
Dust



Quantitative source apportionment of $PM_{2.5}$

- Positive Matrix Factorisation ("PMF")-developed by US EPA
- Aethalometer model: Black carbon (BC)

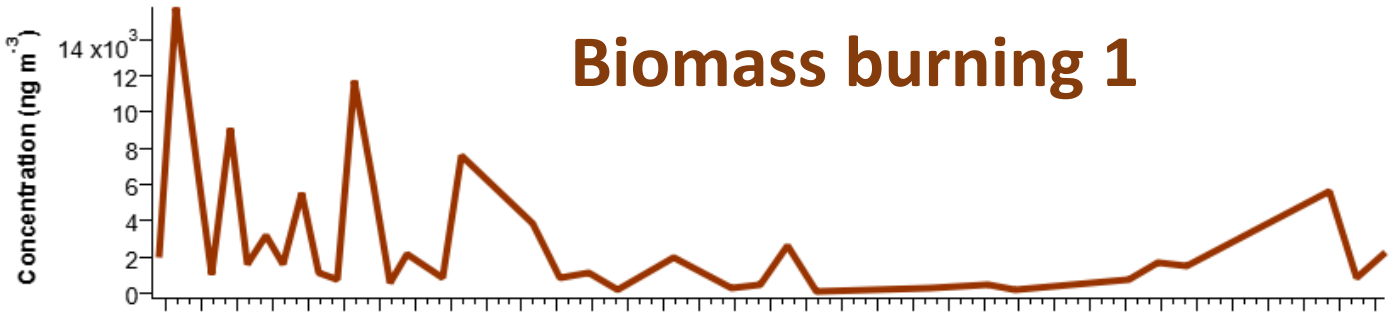
Identified components	% Contribution to PM mass	Concentration (µg m^{-3})
Biomass burning 1	19	1.5
Biomass burning 2	6	0.5
Resuspended dust-and traffic-related	22	1.7
Fuel oil combustion	9	0.7
Sea salt	9	0.7
*Secondary aerosols	25	1.9
Biogenic SOA	10	0.7



*Secondary aerosols – including from power generation, agriculture, traffic

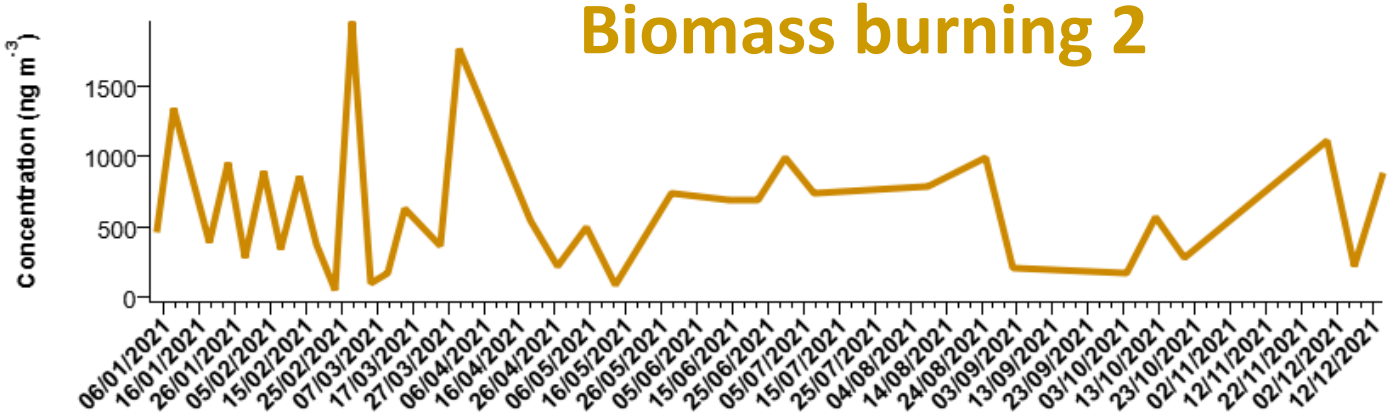
Quantitative source apportionment of $PM_{2.5}$

Biomass burning 1



- ✓ 19% of $PM_{2.5}$
- ✓ Dominated by Sugars (formed via pyrolysis of cellulose) and resin acid
- ✓ Contribution is higher in **winter** than summer
- ✓ Linked to **heating (residential) activities** in winter

Biomass burning 2

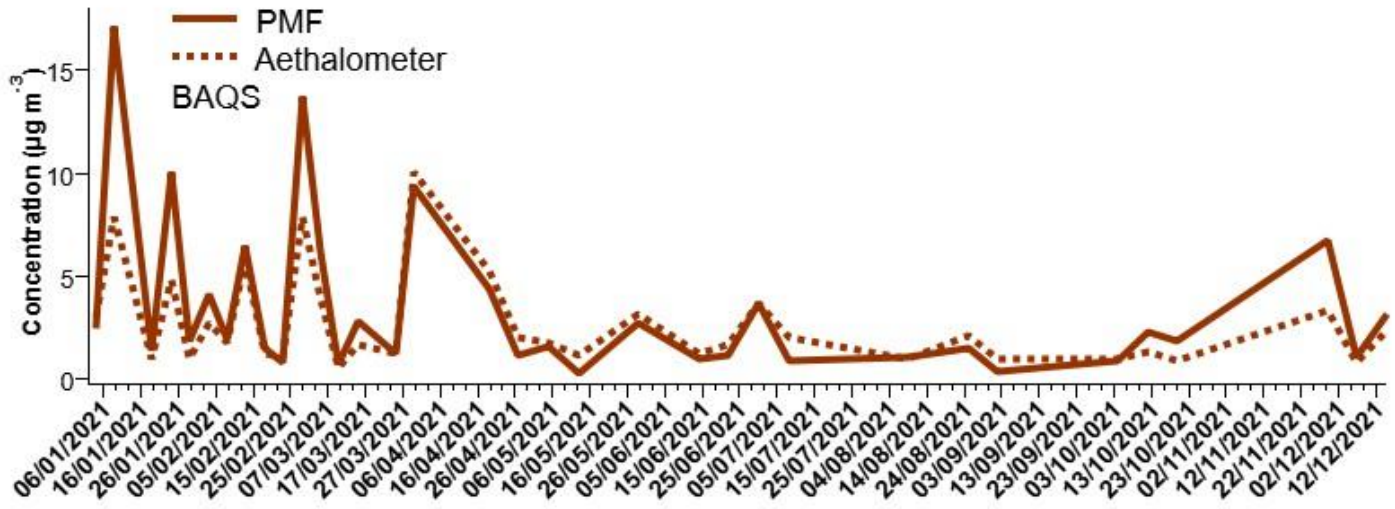


- ✓ 6% of $PM_{2.5}$
- ✓ Dominated by Levoglucosan, a known sugar
- ✓ Significant contribution **year –round**
- ✓ Linked to activities such as **garden waste burning, biomass boilers or barbecues**

- ➢ ***51% of winter primary $PM_{2.5}$ concentrations***

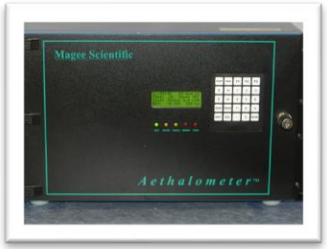
Quantitative source apportionment of $PM_{2.5}$

Biomass burning sources from independent measurements, at BAQS



- ✓ PMF=Biomass burning 1+ Biomass burning 2

- ✓ Aethalometer- Biomass burning contribution measured using aethalometer (BC) data



- ➢ PMF and Aethalometer-model analyses showed consistent results

	Current study	Yin et al.2010	Harrison et al.2012	Harrison et al.2012	Yin et al.2015
Time	2021-2022, winters, BAQS	2007, 2008-winters, BAQS	2007-2008, Birmingham	2010-2011, London	2012-winter, London
Concentrations	2.4 μg m^{-3}	0.07 μg m^{-3}	0.23 μg m^{-3}	0.30 μg m^{-3}	0.15 μg m^{-3}

Implications for policy

- The contribution of biomass burning activities to $PM_{2.5}$ is even higher in the winter, at around 51% of all primary concentrations.
  - Both local and national policy interventions are required to reduce wood burning related $PM_{2.5}$ exposure.

- Traffic-related activities accounted for 22% of the total $PM_{2.5}$ mass.
  - Targeted local policies and change in traffic behaviour can effectively reduce $PM_{2.5}$ exposure from traffic sources.

- Secondary aerosols accounted for a quarter of the total $PM_{2.5}$ mass.
  - Regional and local emission reduction targets can help in reducing secondary aerosol formation (by promoting sustainable farming practices and transitioning towards cleaner technologies).

- The estimated annual mortality attributable to $PM_{2.5}$ in the West Midlands region is 2,070 (via AQ-LAT).
  - Locally targeted interventions, raising awareness about residential wood burning, and enhancing smoke control areas could significantly reduce the mortality and saves lives.

“Thank you”