Sixty years of air pollution measurements in London – evolving techniques and advancing understanding

23rd June 2014
LAQN 21 years

Gary Fuller
We should have seen the warning signs

- Near Liege, the Meuse Valley smog of 1930 killed 60 people in 3 days (Nemory et al 2001)
- Denora, Pensyviana, 1948 killed 20 out of 15,000 inhabitants and left 6,000 ill.
- But they didn’t have measurements
Measurements in 1952
Air pollution aspects of the London fog of December 1952

By E. T. WILKINS
D.S.I.R., Fuel Research Station, Greenwich

Figure 1. Daily air pollution and deaths.
Figure 2. Approximate pattern of pollution by sulphur dioxide, 5 to 9 Dec. 1952.
1970s

- Clean Air Acts and the wide-spread availability of natural gas meant that London smogs were becoming a thing of the past

GLA, 2002
1970s – new insights

• While London was immersed in smoke in LA they were dealing with something different.
  – Eye irritation
  – Aerosol formation
  – Cracking rubber
  – Crop damage

Chemistry and Physiology of Los Angeles Smog

A. J. HAAGEN-SMIT
California Institute of Technology, Pasadena, Calif., and
Los Angeles County Air Pollution Control District, Los Angeles, Calif.

June 1952

INDUSTRIAL AND ENGINEERING CHEMISTRY
1970

- Royal College of Physician’s Report – Air Pollution and Heath
  
  “…customary lack of continued bright sunshine…saves Britain from the photo chemistry that causes Los Angeles type smog.”
Measurements in 1973

Long-range transport of photochemical ozone in north-western Europe

R. A. Cox & A. E. J. Eggleton
Environmental and Medical Sciences Division, AERE, Harwell, Oxfordshire, UK

R. G. Derwent*
Air Pollution Division, Warren Spring Laboratory, Stevenage, Hertfordshire, UK

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Department of Applied Physical Sciences, University of Reading, Reading, Berkshire, UK

D. H. Pack
US Department of Commerce—National Oceanic and Atmospheric Administration, Air Resources Laboratory, Silver Spring, Maryland, 20910

• O3 over levels that would reach ‘high’ on the DAQI over much of the UK in August 1973.

• Goes to show that you should never trust air quality scientist who don’t have supporting measurements
1977 – with London’s air cleared

Scatter diagram of daily apparent smoke concentrations determined by the smoke shade technique vs daily airborne lead concentrations as measured at the County Hall.
1977 – with London’s air cleared

Something not black was there in the PM mass concentration

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Scatter diagram of daily gravimetrically determined particulate concentrations vs daily airborne lead concentrations for the County Hall site.
1993 The advent of the LAQN

London’s air pollution measurement infrastructure and expertise had been largely dismantled

Questions were being asked about the possible public health implications of new industry being proposed for the east Thames corridor.

No London-wide perspective

Some government & local authority measurements but not collected centrally and no consistent QA/QC
1993 The advent of the LAQN

South East Institute of Public Heath (then part of the NHS)

Collaborative agreement with the NHS and the two (!) bodies representing London boroughs

Local authority monitoring sites in
- Bexley, Bromley, City, Greenwich, Islington, Hounslow
- DoE sites in central London

SEIPH provided technical / scientific support, QA/QC, central data collection and public information.
The 1996 PM10 episode

“.. Since PM10 measurements only commenced in the UK in 1992 it is not clear how often we can expect this type of episode again”
Stedman (1996).
1922 - while on holiday in Norfolk, Owens found particulate on winds from the continent and thought this to be due to German industrialization - measured wind speeds by chasing thistle seeds over 50 yards of beach.

Did we miss the secondary PM episodes for most of the 20th century since we were focused on measuring black smoke?
PM10 source apportionment using the whole LAQN

Fuller et al 2002, 2006

\[ Y = 0.11x + 14.1, \quad r = 0.95 \quad n = 55, \quad P < 0.01 \]
PM10 source apportionment using the whole LAQN

Fuller and Green 2006
PM10 source apportionment using the whole LAQN

PM10 at Marylebone Road methods from Fuller and Green 2006

Annual mean ug m$^{-3}$ TEOM*1.3

- Measured PM10
- Non-primary PM10
- Primary PM10

EU Limit Value
But shouldn’t PM10 concentrations be going down?

- PM10 source apportionment showed increasing roadside concentrations
- “De-weathering” local PM10 also showed increases
- But emissions all tend down

Beevers et al 2010,
PM10 apportionment as per Fuller and Green 2006
The network perspective also showed problems with NOX and NO2 fourteen years ago. Beevers et al 2010, Carslaw et al 2001 but also see Clapp and Jenkins 2001 and Carslaw et al 2001.
Measurements in new locations showed extraordinary NO2 where it was not expected.
Unexpected PM10 too – waste sites

Extensive studies since 2000

Data from London Air Quality Network, King’s College London

Annual number of days with mean PM10 > 50 ug m-3

EU ref eq


- Brent 5
- Bexley 2
- Bexley 4
- Ealing 8
- Hastings 1
- Hastings 2
- Lewisham 3
- Sutton 5
- Sutton 7
- Bexley 4 W
- Bexley 4 E

MRC-PHE
Centre for Environment & Health
Unexpected PM10 too – construction sites
First explored in Fuller et al 2004.
Font et al 2014 (in revision) Blue = before, Red = during, Brown = after
PM10 chemical composition

- Mineral & Abrasion Sources
- Marine Aerosol
- Secondary Inorganic Aerosol
- Regional Organic Aerosol
- Local Organic Aerosol
- Traffic

Analysis from David Green, KCL
PM10 chemical composition

Analysis from David Green, KCL
Future - time resolved PM10 composition

- Daily measurements of chemical composition provide limited opportunities to match concentrations to sources

- Time resolved measurements will offer new ways of source attribution
Time resolved PM10 chemical composition

XACT 625 (NERC)
• Real time XRF
• Elemental concentrations in PM
• Hourly time resolution

URG 9000 (DEFRA)
• Real time IC
• Anion and cation concentrations in PM
• Hourly time resolution

Aethalometer (DEFRA)
• Real time black carbon
• 5 min time resolution

Aerosol Chemical Speciation Monitor
• Real time non-refractory aerosol
• Sulphate, nitrate, ammonium, organics
• 15 minute time resolution
• Organic source apportionment (vehicle / biogenic etc) using PMF
• Started with ClearfLo

Analysis from David Green, KCL
“Airmageddon” the so called Saharan sand episode

Analysis from David Green, KCL
“Airmageddon” the so called Saharan sand episode

Analysis from David Green, KCL
And finally back to black stuff in air again
Optical measurements of black carbon on filters

Pam Davy, PhD thesis
Wood burning – solid fuel is back in fashion

When designing the study we feared that our sample size would be too small to detect anything.

Wood burning is mainly winter source. Mean wintertime PM from wood between 1.1 and 2.5 µg m⁻³. Across ten UK cities wood burning comprised ~2 - 7% of annual mean PM10 and 3 - 13% in wintertime.
Wood burning – solid fuel is back in fashion

Fuller et al 2014.
Conclusions

- Air pollution measurements have provided understanding of London’s air. Our 21 years are part of a longer story of new insights.

- The London Air Quality Network is unique:
  - Largest and most advanced air pollution network in Europe.
  - Innovation in measurement techniques and public information.
  - With a university at its centre the network perspective takes us beyond compliance assessment to explain the effects of sources and ultimately their links to health.
  - Essential for optimised policy and to determine if air pollution management working
Public information has come a long way too.