

Foto: Jörg Sintermann, AWEL

Did policies to abate air pollution have an positive effect on Black Carbon ?

Christoph Hueglin

Empa, Materials Science and Technology Laboratory for Air Pollution/Environmental Technology christoph.hueglin@empa.ch



Motivation and Outline

Environmental Pollution 218 (2016) 463-474





Anna Font^{*}, Gary W. Fuller

Environmental Research Group, MRC PHE Centre for Environment and Health, King's College London, London, SE1 9NH, United Kingdom

- ⇒ Trend of Black Carbon (BC) at roadside sites in London (UK)
- Situation in Switzerland



Font and Fuller (2016)

Policies implemented in London to improve air quality

- The Euro emission standards were introduced in the early 1990s to reduce exhaust emissions
- Transport for London (TfL) invested in a program to fit a catalytic diesel particulate filters (CDPF) to its older buses by the end of 2005
- A second bus retrofit campaign with over 1000 Euro III buses fitted with a SCR completed by TfL in 2014. Fitting SCR was prioritized for buses with routes along busy roads in central London
- Other initiatives across London include the Low Emission Zone implemented in 2008 limiting entrance of most polluting diesel Heavy Good Vehicles (HGVs) in London
- The Mayor's Air Quality Strategy in 2010 planned the roll out of new hybrid buses and low-emission buses (Euro IV) (GLA, 2010)
- All these policies have been accompanied by many local-scale schemes implemented by the London's boroughs

⇒ Impact on air quality in London?



Analysis of data from roadside air quality monitoring sites in London

Trends estimated separately for two time periods: 2005-2009 and 2010-2014

Map of roadside air quality monitoring sites in London



KC : Kensington and Chelsea - North Kensington 1 BN1 : Barnet – Tally Ho Corner 2 BT4 : Brent – Ikea 3 BT6 : Brent - John Keble Primary School 4 BX6 : Bexley – Thames Road North FDMS 5 BX7 : Bexley – Thames Road North 6 BX8 : Bexley - Thames Road South 7 BY7 : Bromley - Harwood Avenue 8 CD1 : Camden - Swiss Cottage 9 CD3 : Camden - Shaftesbury Avenue 10 CD9 : Camden - Euston Road 11 CR2 : Croydon - Purley Way 12 CR4 : Croydon - George Stree 13 CR5 : Croydon - Norbury 14 CT6 : City of London - Walbrook Wharf 15 CT8 : City of London - Upper Thames Street 16 CY1 : Crystal Palace - Crystal Palace Parade 17 EA0 : Ealing – Acton Town Hall FDMS 18 EA2 : Ealing – Acton Town Hall 19 EA6 : Ealing - Hanger Lane Gyratory 20 El1 : Ealing - Western Avenue 21 EN4 : Enfield - Derby Road 22 EN5 : Enfield - Bowes Primary School 23 GB0 : Greenwich and Bexley – Falconwood FDMS 24 GB6 : Greenwich and Bexley - Falconwood 25 GN0 : Greenwich - A206 Burrage Grove 26 GN3 : Greenwich - Plumstead High Stree 27 GN4 : Greenwich - Fiveways Sidcup Rd A20 28 GR5 : Greenwich – Trafalgar Road 29 GR7 : Greenwich – Blackheath 30 GR8 : Greenwich - Woolwich Elvover 31 GR9 : Greenwich - Westhorne Avenue 32 HF1 : Hammersmith and Fulham - Broadway 33 HG1 : Haringey – Haringey Town Hall 34 HI1 : Hillingdon – South Ruislip 35 HI2 : Hillingdon - Hillingdon Hospital 36 HI3 : Hillingdon – Oxford Avenue 37 HK6 : Hackney – Old Street 38 HR2 : Harrow - Pinner Road 39 HS4 : Hounslow - Chiswick High Road 40 HS5 : Hounslow - Brentford 41 HV1 : Havering - Rainham 42 HV3 : Havering - Romford 43 IS2 : Islington - Holloway Road 44 KC2 : Kensington and Chelsea – Cromwell Road 45 KC3 : Kensington and Chelsea – Knightsbridge 46 KC4 : Kensington and Chelsea – Kings Road 47 KC5 : Kensington and Chelsea – Earls Court Rd 48 LB1 : Lambeth – Christchurch Road 49 LB4 : Lambeth - Brixton Road 50 LW2 : Lewisham - New Cross 51 ME1 : Merton - Morden Civic Centre 52 MY1 : Westminster – Marylebone Road 53 MY7 : Westminster – Marylebone Road FDMS 54 NM2 : Newham - Cam Road 65 RB3 : Redbridge – Fullwell Cross 56 RB4 : Redbridge – Gardner Close 57 RB5 : Redbridge – South Woodford 58 RI1 : Richmond Upon Thames – Castelnau 59 ST4 : Sutton - Wallington 60 ST6 : Sutton - Worcester Park 61 TH2 : Tower Hamlets - Mile End Road 62 TH4 : Tower Hamlets - Blackwall 63 WA7 : Wandsworth – Putney High Street 64 WA8 : Wandsworth – Putney High Street Facade 65 WM4 : Westminster - Charing Cross Library **Traffic counter**

Trend (ANO₂ 2010-2014)

Wandsworth – Putney High Street Lambeth – Brixton Road Merton – Norden Civic Centre Camden – Euston Road Kensington and Chelsea – Carls Court Rd Kensington and Chelsea – Earls Court Rd Kensington and Chelsea – Kings Road Tower Hamlets – Blackwall Kensington and Chelsea – Cromwell Road Croydon – Norbury Harrow – Pinner Road Westmister – Marylebone Road Sutton – Wołłagiar Road Islington – Holloway Road Sutton – Wallington Sutton – Witage Freet Richmond Upon Thames – Castlenau Infield – Bowes Primary School Greenwich – Pilmstead High Street Havering – Gandre Close Greenwich – Westhorne Avenue Greenwich – Westhorne Avenue Greenwich – Westhorne Avenue Greenwich – Blackheath Ealing Western Avenue Havring – Raihlae Greenwich – Blackheath Ealing Western Avenue Havering – Raihnam Haringey – Haringey Town Hall Hackney – Old Street	┥ <u></u> <u>╶</u> ══┋┋┋┋┋┋┋┋┋┋┋┋┋┋┋╪╪╪╪╧╧╧╧╧╧╧╧┊╴╴╴╴╴	$\begin{array}{c} \cdots & -11.52 \\ \cdots & -10.19 \\ \cdots & -7.6.61 \\ \cdots & -7.6.61 \\ \cdots & -3.9 \\ \cdots & -3.9 \\ \cdots & -3.9 \\ \cdots & -3.2 \\ \cdots & -3.9 \\ \cdots & -3.2 \\ \cdots & -3.0 \\ \cdots & -1.5 \\ \cdots & -2.2 \\ \cdots & -2.2 \\ \cdots & -2.2 \\ \cdots & -3.0 \\ \cdots & -0.4 \\ \cdots & -$	$\begin{array}{c c c c c c c c c c c c c c c c c c c $
Overall (RE)	•	-1.65 [-2	2.27 , -1.03]
-20.00	-10.00 0.00 5.0])	
	trend ∆NO ₂ (µg m ⁻³ year ⁻¹)		



Calculated overall and absolute trends for roadside increments (Δ)

		Increase reflects overall real world emissions from diesel vehicles	Downward trends! Not fully explained by changing traffic counts \Rightarrow Success of abatement policies
Pollutant	Overall trend	2005-2009	2010-2014
$\Delta NO_{\rm X}$	µg m ⁻³ year ⁻¹ % year ⁻¹	0.87 [0.07, 1.68] 1.02 [0.07, 1.96]	-1.11 [-2.27, 0.04] -0.95 [0.04, -1.94]
ΔNO_2	µg m ⁻³ year ⁻¹ % year ⁻¹	1.63 [1.25, 2.01] 10.56 [8.08, 13.04]	-1.65[-2.27, -1.03] -4.84[-2.98, -6.69]
ΔPM_{10}	µg m ⁻³ year ⁻¹ % year ⁻¹	-0.19 [-0.34, -0.03] -3.92 [-0.69, -7.15]	0.07 [-0.13, 0.27] 1.11 [-2.06, 4.27]
$\Delta PM_{2.5}$	μ g m ⁻³ year ⁻¹ % year ⁻¹		-0.70 [-0.97, -0.42] -28.34 [-14.65, -42.03]
ΔCO_2	μ g m ⁻³ year ⁻¹ % year ⁻¹		0.35 [-0.42, 1.11] 2.93 [-4.00, 9.85]
ΔBC	μ g m ⁻³ year ⁻¹ % year ⁻¹		-0.59 [-0.96, -0.23] -11.30 [-3.44, -19.16]
i	No significant overall tre n PM10. Increase in coarse particles offsetti decreasing tailpipe emissions?	nd exp flee traff	nd CO ₂ does not match ectations. Increased it efficiency and reduced fic counts (due to uced road capacity)

Materials Science and Technology

Font and Fuller (2016)

Conclusions

- Strong downward trend of roadside black carbon increment in London (note: results are based on data from only three sites)
- Roadside black carbon and PM2.5 decreased at similar rates at sites with colocated measurements
- Downward trend of black carbon is attributed to the effectiveness of diesel particle filters



Situation in Switzerland: Implemented policies for abatement of diesel soot (black carbon)

- Implementation of the Euro emission standards (beginning 1995)
- Implementation of policies and programs to fit diesel particulate filters to non-road diesel engines (construction machines, ship engines, cargo trains etc.)
- Heavy vehicle charge (LSVA) for kilometers driven on Swiss roads depends on Euro emission standard
- Financial incentives for low-emission busses

⇒ Impact on air quality?



Materials Science and Technology

Rural traffic site Haerkingen



⇒ data filtering (wind direction, wind speed, daytime)

⇒ calculation of roadside increments



Rural traffic site Haerkingen

calculated trend of equivalent black carbon (EBC) roadside increment



Year



Rural traffic site Haerkingen

calculated trends of roadside increments for 2005 - 2016

Strong downward trends! \Rightarrow Success of abatement policies

Pollutant	Unit	TrendDownward trends of NOxChange in NO2 driven by secondary formation
ΔNO_x	ppb⋅m ⁻³ ⋅year ⁻¹	-2.47 [-3.18, -1.72] $NO+O_3 = NO_2+O_2!$
	% year ⁻¹	-2.9 [-3.7, -2.0]
ΔNO_2	ppb·m ⁻³ ·year ⁻¹	0.16 [-0.12, 0.38]
	% year ⁻¹	0.8 [-0.6, 1.9]
Δ CO	ppb·m ⁻³ ·year ⁻¹	-10.93 [-14.64, -7.64]
	% year ⁻¹	-7.3 [-9.8, -5.1]
ΔCO_2	ppm⋅m ⁻³ ⋅year ⁻¹	0.19 [-0.81, 0.97] No significant trend
	% year ⁻¹	0.5 [-2.2, 2.6]
ΔPM_{10}	µg⋅m⁻³⋅year⁻¹	-0.19 [-0.35, 0.09]
	% year ⁻¹	-6.3 [-11.3, 3.0]
Δ PNC	number cm ⁻³ .year ⁻¹	-3172 [-4913, -1903]
	% year ⁻¹	-7.3 [-11.3, -4.4]
Δ EBC	µg⋅m ⁻³ ⋅year ⁻¹	-0.24 [-0.29, 0.21]
	% year ⁻¹	-11.6 [-13.5, 10.4]



Trend of black carbon from traffic (EBC TR) and wood burning (EBC WB)





Trends of black carbon (EBC) and black carbon from traffic (EBC_{TR}) and wood burning (EBC_{WB})

Station	Site type	Trend EBC (μg⋅m ⁻³ ⋅y ⁻¹)	Trend EBC _{TR} (μg⋅m ⁻³ ⋅y ⁻¹)	Trend EBC _{WB} (μg⋅m ⁻³ ⋅y ⁻¹)
Bern-Bollwerk	Urban, Traffic	-0.20 (-0.28, -0.12)	-0.16 (-0.39, 0.04)ª	-0.03 (-0.06, 0.06)ª
Härkingen	Rural, Traffic	-0.19 (-0.21, -0.17)		
Zürich-Kaserne	Urban	-0.08 (-0.10, -0.06)	-0.07 (-0.09, -0.05)	-0.01 (-0.01, 0.00)
Lugano-Università	Urban	-0.17 (-0.19, -0.16)		
Dübendorf	Suburban	-0.07 (-0.09, -0.05)		
Basel-Binningen	Suburban	-0.03 (-0.04, -0.02)		
Magadino- Cadenazzo	Rural	-0.08 (-0.15,-0.05)	-0.09 (-0.15, -0.07)	0.01 (0.00, 0.03)
Payerne	Rural	-0.03 (-0.05,-0.02)	-0.04 (-0.05, -0.03)	0.00 (-0.01, 0.02)
Rigi-Seebodenalp	Rural >1000 m asl	-0.03 (-0.05,-0.01) ^b	-0.04 (-0.06, -0.02) ^b	0.01 (-0.01, 0.02) ^b

^a based on data from 2¹/₂ years ^b based on data from 3¹/₂ years



Conclusions – Trends in Switzerland

- In agreement to the study for London (Font and Fuller, 2016), roadside increment of black carbon is strongly declining in Switzerland
- Other air pollutants also show significant downward trend of roadside increment at the Haerkingen site (e.g. PNC and NO_x)
- Measurements show that policies for abatement of black carbon emissions from road traffic and other diesel engines were in Switzerland remarkably successful
- In contrast, little progress has been achieved for the reduction of black carbon emissions from wood burning appliances





Foto: Jörg Sintermann, AWEL

Thank you!

