

Occupational exposure to respirable dust, crystalline silica and elemental carbon in the London tunnelling environment

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Background

- Few studies specifically focussed on exposures in tunnelling, info on personal exposure lacking
- Exposures inc. respirable dust, respirable silica, and diesel exhaust
- Bakke et al, (2002) reported on Norwegian tunnel construction work
 - 5-21% exceedance of Norwegian OELs
 - EC levels of 100-340 $\mu\text{g}/\text{m}^3$ measured
 - Distinct differences in exposure levels & determinants found for the different jobs



Aims and objectives

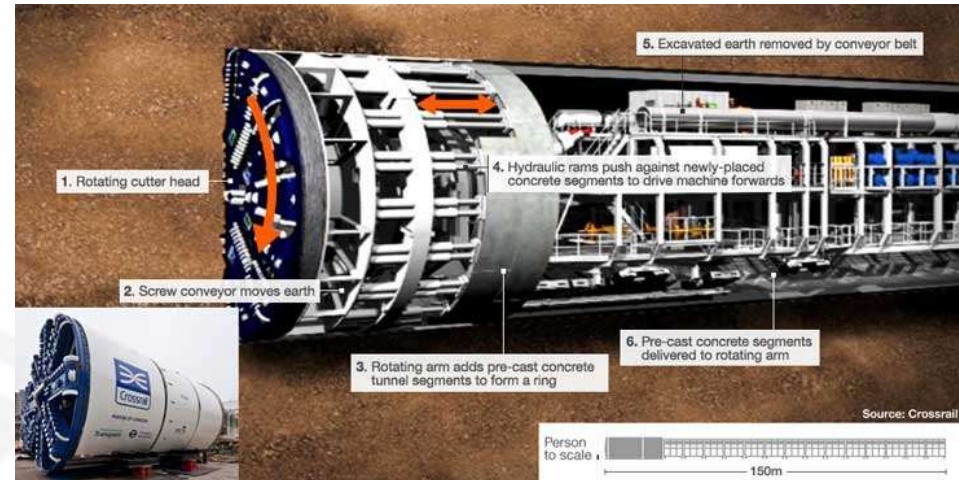
- Measure exposure to respirable dust (RD), crystalline silica (RCS) & elemental carbon (REC)
- Estimate average exposure for workers/occupations likely to have highest exposure levels
- Explore temporal variability of black carbon (BC) & RD exposures
- Compare average exposures to WELS/reference values;
 - RD -
 - 4 mg/m³ 8-hr TWA (HSE WEL)
 - 1 mg/m³ 8-hr TWA (IOM recommended exposure limit)
 - RCS - 0.1 mg/m³ 8-hr TWA (HSE WEL)
 - REC - 100 µg/m³ (reference value)

Tunnelling activities assessed



Sprayed Concrete Lining (SCL)



Tunnel Boring Machine (TBM)



Sampling methods

Area	SCL (2 campaigns)	TBM (2 campaigns)
Campaign focus	RD, RCS	RD, Diesel Engine Exhaust Emissions (DEEE) (measured as REC)
Pumped samples	Cyclone head- PVC filter	Cyclone head - Heat treated quartz filter
Direct reading instruments (both environments)	SidePak AM510 fitted with cyclone 	MicroAeth AE51, with a microCyclone 

Personal sample results (mg/m³)

SCL environment		RD dust (mg/m ³)			RCS (mg/m ³)			
Job title	N	GM	GSD	Max	n<LOD	GM	GSD	Max
Sprayer	11	1.20	2.16	3.20	6	0.02	1.97	0.09
Engineer	9	0.80	1.99	1.70	5	0.03	2.15	0.16
Plant operator	12	0.91	1.80	2.30	5	0.05	2.44	0.20
Back-up sprayer	2	2.35	1.35	2.90	0	0.07	5.80	0.24
Lead miner	7	0.92	2.02	2.70	3	0.03	2.19	0.10
Crack injectors	3	0.85	1.26	1.10	3	0.02	1.00	0.02
Pumpman	4	0.49	1.26	0.60	3	0.04	2.44	0.09
Inspector	1	0.30		0.30	1	0.02		0.02

TBM environment		RD (mg/m ³)			REC (mg/m ³)		
Job title	N	GM	GSD	Max	GM	GSD	Max
Segment lift	8	0.30	2.41	1.38	0.02	1.47	0.04
Lead miner	1	0.14		0.14	0.01		0.01
Engineer	6	0.52	1.79	0.96	0.02	1.42	0.03
Grout pump	5	0.66	1.58	1.10	0.02	1.37	0.03
TBM driver	5	0.48	1.59	0.96	0.02	1.36	0.03
Ring building	3	0.72	1.66	1.10	0.02	1.50	0.03
Loco driver	2	0.89	1.12	0.96	0.02	1.21	0.02
Rail extension	2	1.09	1.19	1.24	0.03	1.25	0.03
Conveyor extension	2	1.64	1.13	1.79	0.03	1.10	0.03
Pipe/walkway extension	2	0.73	1.49	0.96	0.02	1.12	0.02

MicroAeth black carbon results ($\mu\text{g}/\text{m}^3$)

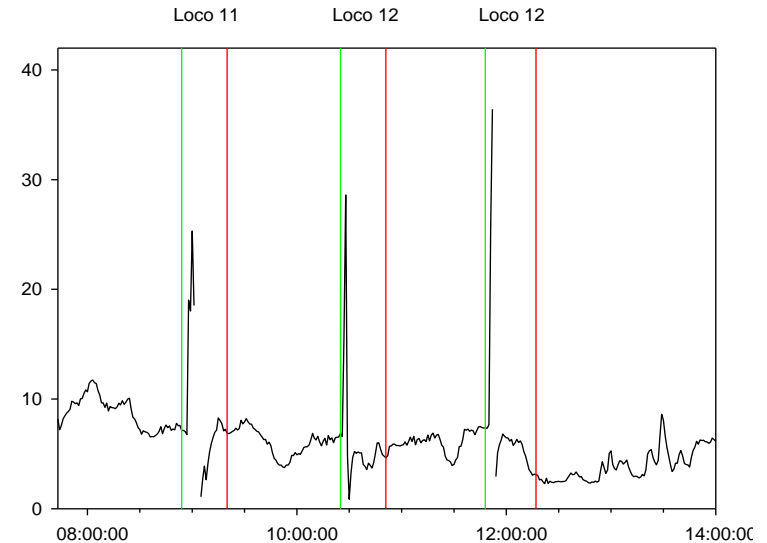
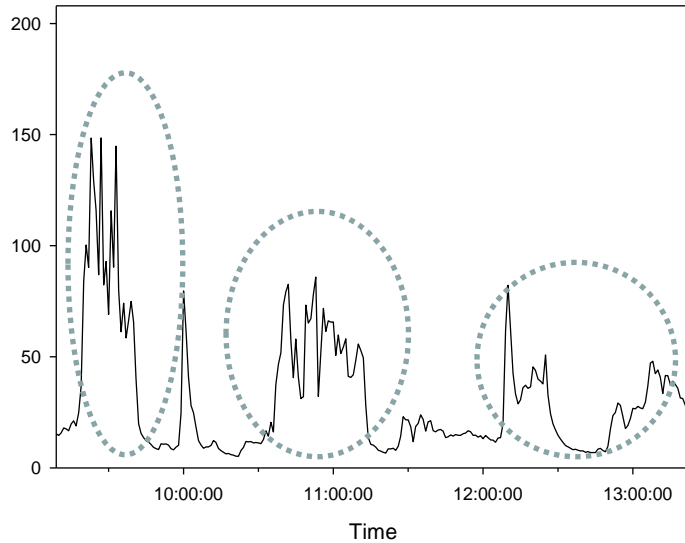
SCL environment

Date	GM	GSD	Min	Max
06/08/14	27.30	1.43	15.51	65.47
07/08/14	37.17	1.43	15.86	137.10
08/08/14	53.79	1.41	23.88	206.47
04/11/14	22.34	2.24	5.21	148.51
05/11/14	17.82	1.62	5.07	84.49
06/11/14	19.82	1.64	7.00	72.35

TBM environment

Date	GM	GSD	Min	Max
25/11/14	4.44	1.54	2.35	17.78
26/11/14	6.22	1.31	2.84	25.77
27/11/14	5.59	1.58	0.86	36.42
10/12/14	4.05	1.89	0.95	25.31
11/12/14*	6.10	2.27	0.12	40.78
12/12/14	2.59	1.74	0.09	9.89

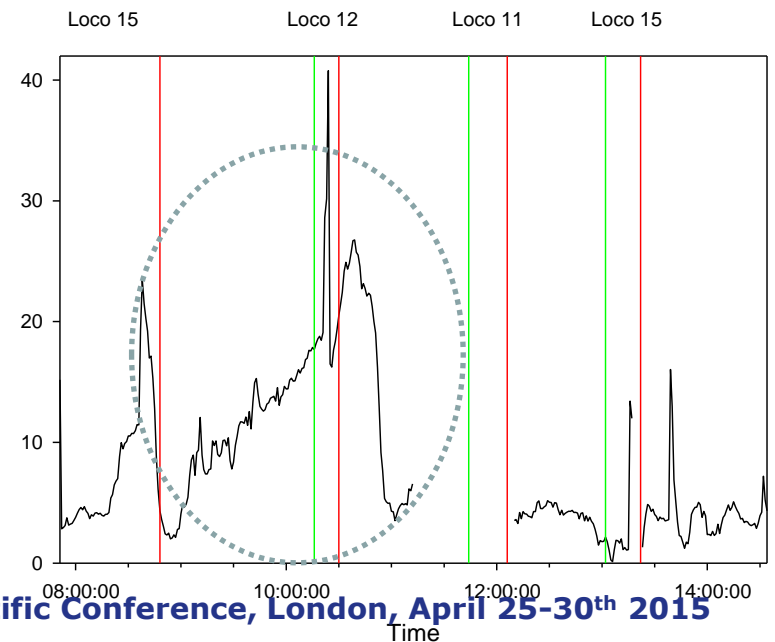
Some temporal black carbon results



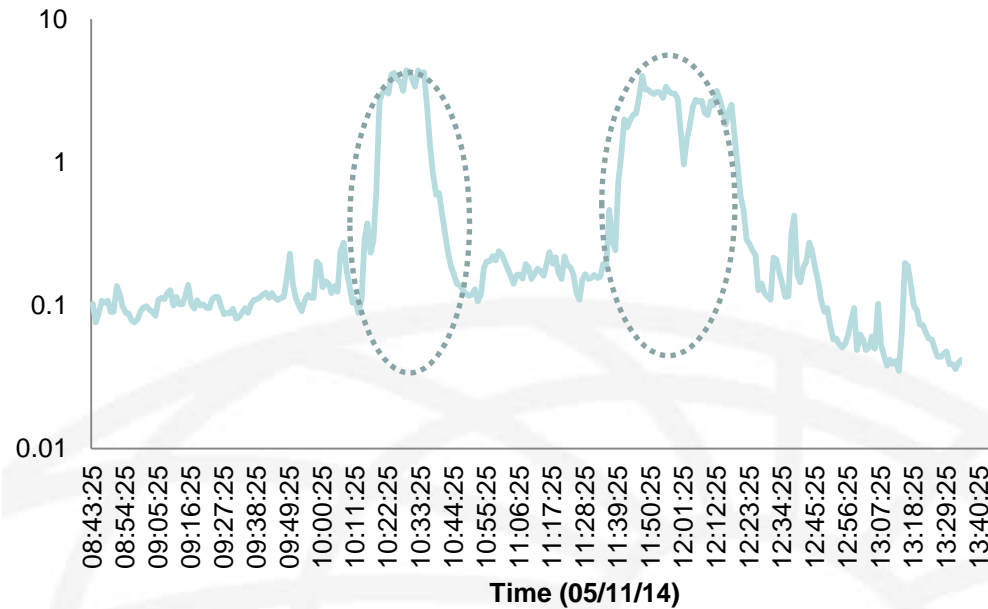
- SCL above** circled areas highlight plant movement during
- 1st & 2nd excavation activities
 - 3rd spraying activities

TBM to right

- **Green lines** entry of loco into TBM
- **Red lines** exit of loco from TBM

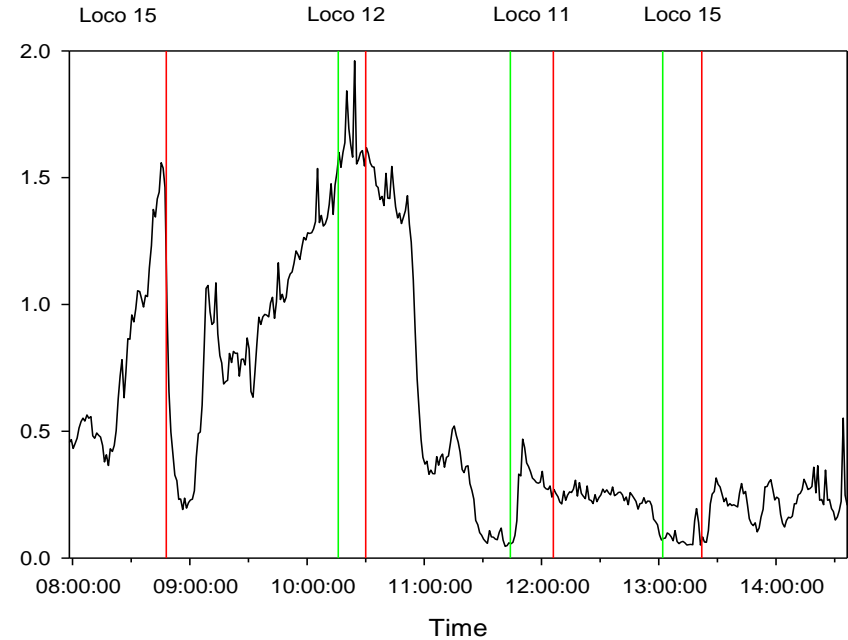


Some temporal respirable dust results



SCL

Circled areas spray activities



TBM

Period when supply air turned down and increased to usual setting

(similar trend in BC data)

Discussion



- Large scale construction projects offer opportunity to collect and store large sets of occupational hygiene data
- Results suggest BC exposures higher in SCL environments than TBM, recommended that future monitoring campaigns should focus on assessing DEEE exposures here
- Bakke et al (2001) reported highest RD GM exposures for shotcreters, shaft drillers and TBM workers, ranging from 2-3 mg/m³. GMs in our monitoring campaigns lower, with the exception of the SCL back-up miner (GM=2.35 mg/m³, n=2)

SCL environment

- RD – all conc. below HSE WEL, several occasions 8-hr TWA exceeded 1 mg/m^3 (IOM recommended exposure limit)
- RCS several occasions 8-hr TWA in excess of 0.1 mg/m^3 WEL (back-up sprayer, engineer, lead miner & two operators)
- Sprayers & engineers wear powered visors when spraying, other operators within restricted area provided with disposal P3 respirators
- Excavation and spray activities lead to increases in BC concentrations due to use of diesel powered engines
- Measures should be taken to reduce these exposures as low as is reasonable practicable



TBM environment

- REC all concentrations $< 0.1 \text{ mg/m}^3$
- RD- all conc. below HSE WEL, several instances where RD 8-hr TWA in excess of 1 mg/m^3 (IOM recommended exposure limit)
- Conveyor extension and rail extension operators reporting highest RD and REC concentrations. Further controls necessary
- REC and BC exposures
 - Entry and exit of locos into TBM had impact on exposure levels
 - Locomotive engines reported to have better extraction systems. Older models - exposures related to those not determined
- Supply air to TBM turned down during controlled activities, impact on concentrations evident



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