Highly time- and size-resolved measurements of trace elements in London during ClearfLo

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Introduction

The identification and quantification of **particle sources** has long proven challenging due to the complex composition of ambient aerosols.

Measurements of **trace elements** provide uniquely source-specific information; barium (Ba) and copper (Cu) are e.g. primarily emitted by traffic sources, while vanadium (V) and nickel (Ni) are linked to heavy oil combustion, whereas sodium (Na) and magnesium (Mg) are tracers for sea salt.

The power of source apportionment by trace elemental analysis is greatly enhanced by simultaneous measurements of **complementary aerosol species**, such as organics, black carbon and nitrogen oxides. Analysis of **meteorological conditions** will further improve the source separation of the trace elements, e.g. by identifying air mass origins via back trajectory analysis.

Motivation

The **ClearfLo** (Clean Air for London) **2012 field campaign** is a multinational collaborative effort to investigate boundary layer pollution in and around London, UK.

Measurements of trace elements identify (at least some of) the **pollution sources**. Highly time- and size-resolved measurements greatly help in this.

A sufficient **temporal resolution** enables to distinguish sources with different characteristic diurnal patterns, such as traffic rush hour peaks and more continuous sea salt influences. **Size-resolved** measurements can help resolve different source classes with similar composition, e.g. iron (Fe) from resuspension appears in $PM_{10\text{-}2.5}$ while brake wear processes appear in $PM_{1.0\text{-}0.1}$.

Particulate matter sampling

Sampling took place during two **Intensive Observation Periods** (IOPs; Fig. 1)

- Marylebone Road, North Kensington and Detling -- 11 Jan – 8 Feb 2012
- Marylebone Road, North Kensington -- 18 July – 22 Aug 2012

Fig. 1. Sampling locations for trace elements (circled) during winter and summer IOP, ClearfLo 2012. Additional measurements at Harwell, Chilbolton and the elevated site BT tower.

Instruments

Rotating Drum Impactors (RDIs) collected particles in three size bins

$PM_{10\text{-}2.5}$ & $PM_{2.5\text{-}1.0}$ & $PM_{1.0\text{-}0.1}$

with a high time resolution of **2 hours** (Bukowiecki et al., 2005). Deposition of particles was done on 6 µm PP foil, mounted on aluminium wheels (Fig. 2).

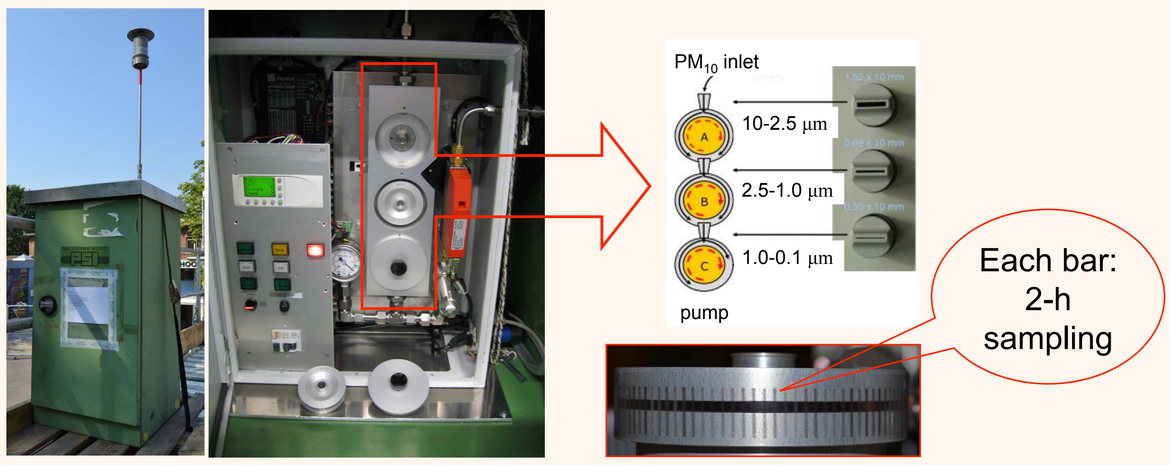

Fig. 2. Rotating drum impactor in waterproof housing (left), inside of the instrument (centre), a scheme showing the air flow through the instrument (right top), and an aluminium wheel with deposited particles in a bar-like structure (right bottom).

Acknowledgement

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References

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Trace elemental analysis

The trace elemental composition of the samples is analyzed by synchrotron radiation induced X-ray fluorescence spectrometry (**SR-XRF**) at the Swiss Light Source (SLS, Paul Scherrer Institute, CH) and at HASYLAB (Deutsches Elektronen-Synchrotron, DE) (Richard et al., 2010; Fig. 3).

The RDI SR-XRF setup provides quantification of **Na (sodium) – Pb (lead)**.

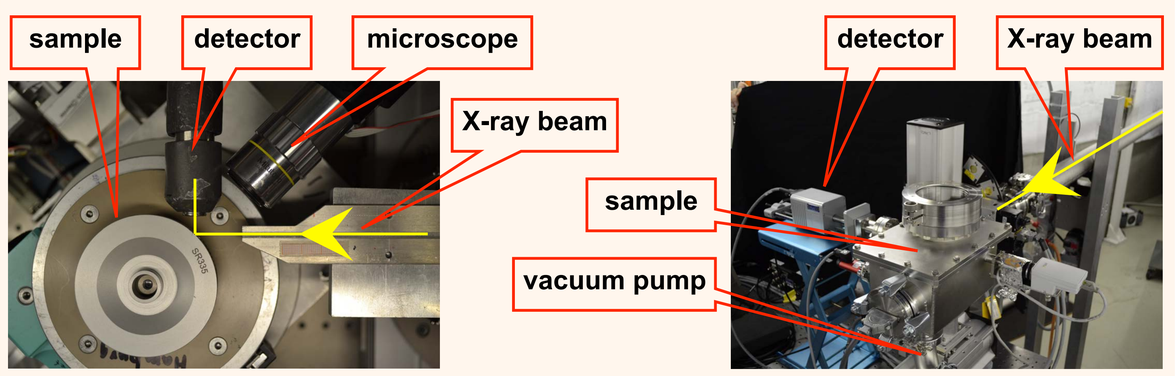

Fig. 3. SR-XRF setup at HASYLAB, Beamline L (left) and at SLS, Optics beamline (right).

Results

- Trace elements related to **traffic** are **enhanced** at the heavy traffic site (Marylebone Road) compared to the urban background site (North Kensington) and the rural site (Detling). Examples:

  Fe (iron), Sb (antimony) and Ba (barium) from brake wear

  Al (aluminium), Si (silicon) and Ca (calcium) from mineral dust resuspension

- Trace elements **advected** from emission sources to the measurement sites show very **similar** concentrations at all sites. Examples:

  Na (sodium), Mg (magnesium) and Cl (chloride) from sea salt

  S (sulphur) and K (potassium) in $PM_{1.0\text{-}0.1}$ from regional biomass burning

- **Diurnal variations** of elements indicate pollution influences such as elevated concentrations during rush hours or day time, or a rather flat pattern at sites away from local sources (Fig. 4).

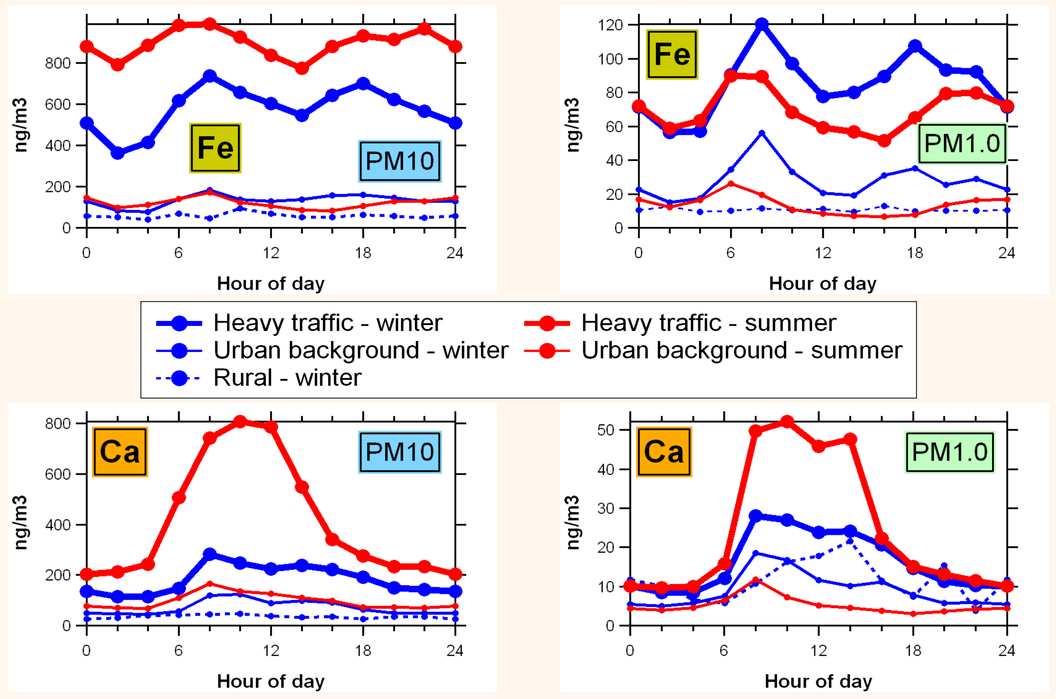

Fig. 4. Mean diurnal variations of Fe and Ca both for $PM_{10\text{-}2.5}$ and $PM_{1.0\text{-}0.1}$ for 3 sampling sites in the winter IOP and 2 sampling sites in the summer IOP during ClearfLo 2012.

Conclusions & Outlook

- In two IOPs of the ClearfLo 2012 **measurement campaign**, particles have been sampled with rotating drum impactors in London, UK. Subsequent SR-XRF was used to quantify the **trace elemental composition** of the particles.

- **Size-segregation** into $PM_{10\text{-}2.5}$, $PM_{2.5\text{-}1.0}$ and $PM_{1.0\text{-}0.1}$ resolved different **source classes** of the same element such as K from wood burning in $PM_{1.0\text{-}0.1}$ and resuspension of mineral dust in $PM_{10\text{-}2.5}$.

- A **sampling time of 2-h** enabled the characterization of sources with different **diurnal patterns**. Fe e.g. is directly related to traffic volumes, showing distinct rush hour peaks, whereas Ca depends on the amount of mineral dust available for resuspension by traffic, showing a large peak throughout the day.

Outlook

- Source separation will be enhanced by the use of statistical methods such as **Positive Matrix Factorization** and **Multilinear Engine** (Paatero 1997, 1999).

- **Correlations** with meteorological conditions, gas and particle phase species will help to understand observed trends and identified sources of trace elements.