Non-exhaust contributions to PM levels in 5 EU cities

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AIRUSE

Testing and Development of air quality mitigation measures in Southern Europe

Duration: 2012-2016

Coordinator
CSIC, Spanish Research Council

Associated beneficiaries
• DEMOKRITOS, Greece
• University of Aveiro, Portugal
• University of Florence, Italy
• Institute of Ceramic Technology, Spain
• ARPA Lombardia, Italy
• University of Birmingham, UK
OBJECTIVES

- Characterizing similarities & differences in PM sources & contributions across Southern EU (Porto, Barcelona, Milan, Florence and Athens)
- **Develop, test and propose specific and non specific measures** to abate urban ambient air PM in Southern EU, to meet AQ standards & to approach WHO guidelines.

**Specific PM mitigation measures**

- Street washing & dust suppressants for road dust
- Biomass burning
- Industrial emissions
- LEZ, eco-efficient vehicles, labelling, shipping, ...

http://airuse.eu
http://airuse.eu/en/outreach-dissemination/reports/
Methods

- **Urban background sites**: Barcelona, Porto, Florence, Athens
  January-December 2013 (1/3 days)

- **Traffic sites**: Barcelona, Porto, Florence, Athens
  Intensive campaigns

**Barcelona (UB)**
Sample treatment

**Thermal optical analysis:** EC, OC

**Ion Chromatography:**
\[ \text{NO}_3^-, \text{Cl}^-, \text{SO}_4^{2-}, \text{NH}_4^+ \]

**ICP-AES:**
Al, Ca, K, Na, Mg, ...

**ICP-MS:**
Li, Be, Sc, Ti, V, Cr, Mn, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Rb, ...

- Levoglucosan for biomass burning
- Inorganic tracers (carbonate) for African dust
- Intercomparison with XRF, PIXE

>2000 filters analyzed
PMF: positive matrix factorization

\[ x_{ij} = \sum_{k=1}^{p} g_{ik} f_{jk} + e_{ij} \quad i=1,2,\ldots,m \quad j=1,2,\ldots,n \]

\[ Q = \sum_{i=1}^{m} \sum_{j=1}^{n} \left( x_{ij} - \frac{\sum_{k=1}^{p} g_{ik} f_{jk}}{\sigma_{ij}^2} \right)^2 \]

USEPA PMF v5

- No need of full source profiles
- Partial information about sources can be used
3 traffic sources identified

- Fe at all sites
- Ca in BCN
- EC in POR, MLN and FI
- S in ATH

OC/EC:
- <1 at POR-TR
- 1.8-3.7 at UB sites
- 16.4 at ATH-SUB (low diesel)

Mainly NH$_4$NO$_3$ and OC
NaNO$_3$ in ATH-SUB
PM10: Annual mean

Total traffic: 1st source at all sites
22-36% of PM10

Non-exhaust: 1.8-3.4 µg/m³
9-11% of PM10
Days with >50 µgPM10/m³

Non-exhaust: 2.2-11.8 µg/m³
3-14% of PM10
Total traffic: 1\textsuperscript{st} source at MLN, POR and FI
2\textsuperscript{nd} source, at BCN and ATH
26-39\% of PM2.5 (22\% ATH)

Non-exhaust: 0.2-2.6 µg/m\textsuperscript{3}
1-9\% of PM2.5
At background PM10, Exhaust and Non-exhaust contributions are nowadays similar.

In PM2.5 Exhaust generally dominates.
Time variability

**Exhaust**

**Non-exhaust**

**Nitrate**
Contribution to elements/compounds

Athens SUB

Barcelona UB

Porto TR
Can we separate better?

Comparison with experimental profiles

1-hour resolved measurements
Experimental profiles: Road dust


Road dust Loading mg/m²

IDPS: Inhalable Deposited Particle Sampler (CSIC patent)
Experimental profiles: Road dust
Urban and street level modelling

URBIS model (Amato F., Zandveld P. et al., 2016)
## Experimental profiles: Brake pads and Tires

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PMF profiles vs Experimental profiles

PMF profiles
- Brake pads
- Tires
- Road dust

Experimental profiles
- Barcelona
- Athens
- Mean road dust
- BCN-UB
- MLN-UB
- POR-TR
- FI-UB
- Mean brake
- Bike Brake UK
- Tire JP brand
- Tire FR brand
1-hour resolution measurements

Streaker Sampler

PIXE analysis

\( \text{PM}_{2.5} \quad \text{PM}_{2.5-10} \)
Hourly measurements

Road dust
Athens ATH-SUB
Hourly measurements

- Metallurgy

- Biomass burning
Conclusions

1. Traffic is **29-36% of PM10 (22% ATH), 26-39% of PM2.5 (22% ATH)**

2. Non-exhaust is **9-11% of PM10 (1.8-3.4 µg/m³), comparable to exhaust**

3. Non-exhaust is the main source of Cu, Fe, Sb, Zn, Cr, Ba, Sn, Ni...

4. In **PM2.5, exhaust contribution generally dominates**

5. Non-exhaust burden generally **increases during PM10 exceedances**

6. Non-exhaust contribution is more related to:
   - **Resuspension** (in Barcelona and Athens)
   - **Brake wear** (in Porto, Florence, and Milan)