Trace element analysis of size classified aerosol particles

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Introduction

Sampling with the cascade impactor
Measurements by SEM – EDXA
Measurements by ETV-ICP-MS
Catalyst borne elements in Berlin air
Air borne elements over the Atlantic Ocean

Conclusion

XXXII CSI, Pretoria, South Africa
Atmospheric particles

Natural sources: volcanism, mineral dust, biomass burning, sea spray

Composition: Na, Mg, K, Sr, Si, Al, Ca, Fe, Ti, S, Mn, Ba...

Anthropogenic sources: power plant, waste incineration, industrial processes, transportation

Composition: Be, Cd, Hg, Mo, Ni, Sb, Se, As, Sn, V, Cr, Cu, C, Pb, Pt...
Atmospheric particles

The composition of aerosol particles is determined by the course of chemical and physical reactions occurring in particle generation and transportation.

Required monitoring: Relevant sources, Deposition, Atmospheric monitoring, Effect on man and environment,

Measurable property: Chemical composition, Shape, Number of particles, Size distribution
Cascade Impactor

\[ d_{ae} = \sqrt{\frac{D}{U}} \times \left( \frac{9 \eta St}{C \rho} \right) \]

dae : 16.5 µm ..... 0.35 µm
aerodynamic diameter
D : 2.7 mm ...... 0.35 mm
diameter of the orifice
U : 48.0 cm/s ... 7057 cm/s
lineare gas velocity
\( \eta \) : gas viscosity
St : Stokes number
C : Cunningham factor
\( \rho \) : particle density

Air in
to vacuum pump, controlled flow rate 2.2 m³/h

Stage 1
Nozzles plate
Impaction plate
Stage 2
target
Stage N
Back-up filter
SEM picture of a graphite target with impacted particulates
Experimental set-up for ETV-ICP-MS

Fixing slits
Impaction area
Particulates
Injection hole
Graphite target
Graphite tube container

Elan 5000
Quadrupole
Ion lenses
Turbo pump
Turbo pump
Turbo pump
System computer
Pump
Pump
RF supply
Plasma gas
Auxiliary gas
Stabilization gas
Target
Pivot
Iridium tube container
Graphite target
Graphite target
Particulates
Injection hole
Fixing slits
Impaction area
Limits of detection, based on the $3\sigma$ criteria

<table>
<thead>
<tr>
<th>Measured isotope</th>
<th>$^{55}$Mn</th>
<th>$^{59}$Co</th>
<th>$^{105}$Pd</th>
<th>$^{107}$Ag</th>
<th>$^{111}$Cd</th>
<th>$^{118}$Sn</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOD pg/m³</td>
<td>1</td>
<td>0.8</td>
<td>0.2</td>
<td>0.03</td>
<td>0.2</td>
<td>0.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measured isotope</th>
<th>$^{121}$Sb</th>
<th>$^{130}$Rh</th>
<th>$^{140}$Ce</th>
<th>$^{195}$Pt</th>
<th>$^{205}$Tl</th>
<th>$^{208}$Pb</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOD pg/m³</td>
<td>1</td>
<td>0.1</td>
<td>3</td>
<td>0.6</td>
<td>0.05</td>
<td>0.2</td>
</tr>
</tbody>
</table>
Sampling conditions:
Location:
  40 km north-west of town centre,
  4 m above ground;
Time: 76 h;
Volume:
  0.93 m³ per target
Platinum group elements in Berlin air correlated to Ce
### Mean concentration of platin group elements in Berlin air

<table>
<thead>
<tr>
<th>Isotope</th>
<th>$^{140}$ Ce</th>
<th>$^{103}$ Rh</th>
<th>$^{105}$ Pd</th>
<th>$^{195}$ Pt</th>
<th>$^{140}$ Ce : $^{195}$ Pt</th>
<th>Maximum in particle distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plume of Berlin</td>
<td>250 ± 25</td>
<td>4 ± 1</td>
<td>8 ± 1</td>
<td>7 ± 1</td>
<td>0.903</td>
<td>3 - 5µm</td>
</tr>
<tr>
<td>Motorway tunnel</td>
<td>1140 ± 100</td>
<td>28 ± 5</td>
<td>16 ± 2</td>
<td>35 ± 6</td>
<td>0.899</td>
<td>7 µm</td>
</tr>
</tbody>
</table>
Satellite picture of Sahara dust
Research vessel „Polarstern“
On board sampling station

Sampling conditions:
Daily aerosol sampling,
22 m above sea level
Time: 23 h
Air volume: 0.3 m³ per target
Polarstern Cruise ANT XVII/1
Particles of the 1.1 µm stage
(site of sampling: the British Channel)

Philips XL 30 ESEM

XXXII CSI, Pretoria, South Africa
SEM-EDX analysis

XXXII CSI, Pretoria, South Africa
Particles of the 3.5 µm stage
site of sampling 14°N (Sahara dust)
SEM-EDX analysis

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Manganese

[Graph showing the distribution of manganese in different aerodynamic diameters across various latitudes.]

XXXII CSI, Pretoria, South Africa
Spatial distribution of element concentrations in aerosol over the Atlantic Ocean

- In
- Ag
- Sn
- Cs

Latitude North
# Mean element concentration in aerosol

*(pg / m³)*

<table>
<thead>
<tr>
<th>Element</th>
<th>North Atlantic</th>
<th>Region of Sahara dust</th>
<th>South Atlantic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>52°N - 22°N</td>
<td>22°N – 6°N</td>
<td>6°N – 31°S</td>
</tr>
<tr>
<td>Ag</td>
<td>580 ± 130</td>
<td>220 ± 50</td>
<td>270 ± 50</td>
</tr>
<tr>
<td>Sb</td>
<td>1100 ± 290</td>
<td>300 ± 25</td>
<td>260 ± 60</td>
</tr>
<tr>
<td>Tl</td>
<td>28 ± 4</td>
<td>78 ± 20</td>
<td>16 ± 3</td>
</tr>
<tr>
<td>Sn</td>
<td>3950 ± 860</td>
<td>20800 ± 5100</td>
<td>1970 ± 470</td>
</tr>
<tr>
<td>Mn</td>
<td>3600 ± 870</td>
<td>15000 ± 2000</td>
<td>2480 ± 550</td>
</tr>
<tr>
<td>Pb</td>
<td>18200 ± 2800</td>
<td>18900 ± 1800</td>
<td>13600 ± 2600</td>
</tr>
<tr>
<td>Cs</td>
<td>21 ± 9</td>
<td>215 ± 65</td>
<td>21 ± 7</td>
</tr>
<tr>
<td>In</td>
<td>920 ± 300</td>
<td>520 ± 150</td>
<td>940 ± 300</td>
</tr>
<tr>
<td>Bi</td>
<td>250 ± 40</td>
<td>450 ± 50</td>
<td>200 ± 30</td>
</tr>
</tbody>
</table>
Conclusion

- Size classified sampling of aerosol particles on separate graphite targets and subsequent multielement analysis is a useful tool for the characterization of aerosol particles.

- The high efficiency of the sampling system combined with the powerful analytical technique permits the study of isotope correlations allowing the identification of particle sources as well as transport and deposition processes.
Acknowledgement

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