

Passive Sampling Technique Sigma-2, Operational Application and Validation of Automated Optical Single-Particle Analysis in the Size Range for 2.5 - 80 μm

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Research Center Human - Biometeorology, Freiburg i.Br. - Air Quality Department

Measuring Air Pollutants by Diffusive Sampling and Other Low Cost Monitoring Techniques
Krakow, 15th -17th September 2009

Passive sampling technique Sigma-2, operational application and validation of automated optical single-particle analysis in the size range 2.5 – 80 μm

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Air quality department in Freiburg is responsible for:

- Operational air quality measurements in German spas.
- Research projects and air quality studies in collaboration with Universities and medical institutions.
- Further development of basic methods and instructions for applied research of air quality measurements and assessment procedures (e.g. VDI guidelines).

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- **Motivation**
- **Instruments and Methods**
- **Results**
 - Soluble aerosol particles 2.5-10 μm (sea salt)
 - Mineral aerosol particles 2.5-10 μm (Saharan dust events)
- **Summary**
- **Outlook**

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Motivation to measure coarse particles

- Measurement of the PM10 fraction represents only a small part of „all“ coarse mode particles.
- Traffic-caused dust suspension of PM10 will be significantly underestimated (e.g. road and tire abrasion).
- Biological particles are only partially (spores) sampled in the PM10 fraction, or not at all (pollen).
- At coastside areas sea salt particles (dp 2.5 – 10 μm) are a substantial contribution of the PM10 fraction depending on meteorological conditions.
- Sporadic Saharan dust events may lead to particulate concentrations that exceed the air quality standard (e.g. PM₁₀ 50 $\mu\text{g}/\text{m}^3$ 24h mean).
- Saharan dust aerosols have an influence on nutrient dynamics and biogeochemical cycling of terrestrial and oceanic ecosystems.

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Instruments and Methods

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Acceptor:

Sticky collection plate 67 x 67 mm :
Clear base foil

Adhesive:
Acrylestherpolymerisate

Preparation for microscopy:
15x15mm part of the foil embedded for the automated optical single-particle analysis.
Aqueous solution, refractive index: $n_{\text{aq}}=1.432$

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Single particle analysis obtained with a motorized transmitted light microscope (200x mag). Using an adapted scanning stage, digital autofocus, CCD-Digital Camera and automated Image Processing System.

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Ambient air aerosol sample (Sigma-2)

Automated microscopy analysis:

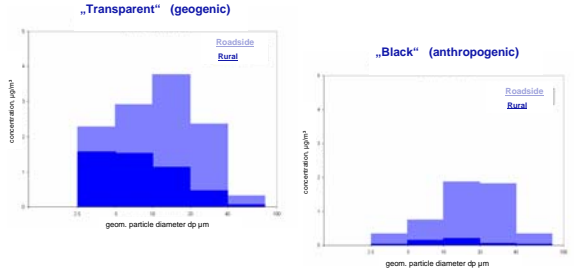
1. Particle detection
2. Size measurement
3. Densitometric measurement
4. Concentration and size distribution calculation

"Transparent" mineral (without pollen) and "black" anthropogenic (BC) components.

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Typical size distribution of „transparent“ (geogenic) and „black“ (anthropogenic) atmospheric particles, $dp > 2.5 \mu\text{m}$ for two different locations in a German health resort.



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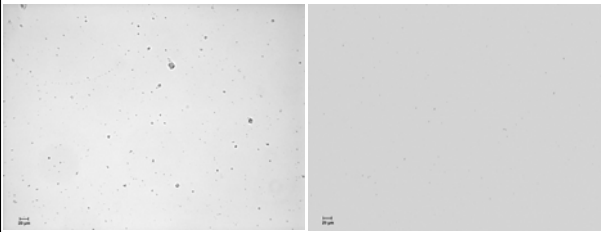
Maritime Aerosol
Measurement of sea salt particles (dp 2.5-10 μm)

- Size distribution
=> Maximum 3 - 10 μm [L. Morawska et al., 1999]
- Settling rate > 1 cm/s
=> Sedimentation sampler
- Increasing distance from the coast line
=> Decrease in concentration
=> Decrease in size
- Analytics
=> Microscopic particle analysis > Particles > 2.5 μm
=> Ion Chromatography analysis > Total Particles

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Sample of sea salt particles (Westerland/Sylt, exposure time 12.12. - 19.12.2003)



Embedded in an **anhydrous** immersion medium Embedded in an **aqueous** immersion medium

Calculation method of **anhydrous** and **aqueous** embedded aerosol samples


$36 \mu\text{g}/\text{m}^3 - 2 \mu\text{g}/\text{m}^3$
= 34 $\mu\text{g}/\text{m}^3$ soluble particles („NaCl“)

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Verification of the microscopic analysis with ion chromatography (IC)



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Results and Verification

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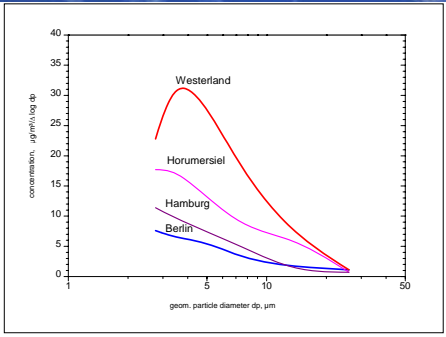
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Location	Ion chromatographic (total)		Microscopic (2.5 - 10 μm)	
	Na ⁺ + Cl ⁻	Na ⁺ · 2.54	·NaCl ⁺	
	Deposition \pm SD		Concentration \pm SD	
		[$\mu\text{g}/\text{m}^2 \cdot \text{d}$]	[$\mu\text{g}/\text{m}^2 \cdot \text{d}$]	[$\mu\text{g}/\text{m}^3$]
Westerland	1896 \pm 1440	1831 \pm 1380	988 \pm 583	13,9 \pm 7,7
Horumersiel	1015 \pm 957	942 \pm 813	842 \pm 816	8,7 \pm 7,5
Hamburg	481 \pm 417	506 \pm 424	264 \pm 181	3,7 \pm 3,0
Berlin	247 \pm 181	256 \pm 195	323 \pm 351	3,4 \pm 3,0

Ion chromatographic (total) and microscopic (size fractioned) sea salt measurements on deposition samples with the passive sampler Sigma-2, from 25.09. - 30.12.2003.

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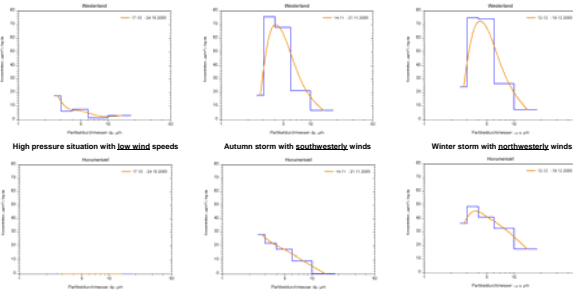
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Smoothed average size distribution of „water soluble“ atmospheric particles $d_p > 2,5 \mu\text{m}$ (·NaCl⁺) sampled at four different locations from 25.09 - 30.12. 2003.

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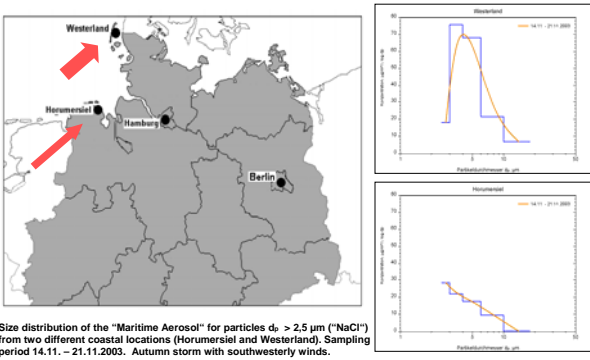
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Size distribution of atmospheric water soluble particles (·NaCl⁺) sampled at two different coastal locations from 25.09 - 30.12. 2003 depending on different meteorological conditions.
Size intervals: 2.5- 3, 3-4, 4-6, 6-10, 10-18 μm

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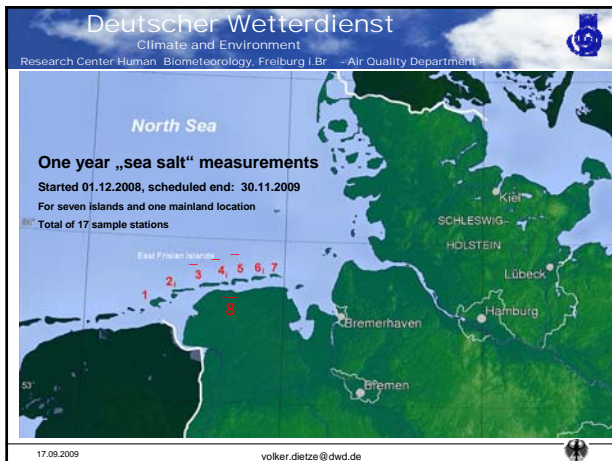
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Size distribution of the "Maritime Aerosol" for particles $d_p > 2,5 \mu\text{m}$ (·NaCl⁺) from two different coastal locations (Horumersiel and Westerland), Sampling period 14.11. - 21.11.2003. Autumn storm with southwesterly winds.

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Preliminary results of the operational „Sea Salt“ measurements
05.12.2008 - 08.05.2009 (At this time no QA/QC procedures. Plausibility checked)

Location	Ion chromatographic (total)		Microscopic (2.5 - 10 μm)	
	Na ⁺ + Cl ⁻	Na ⁺ - 2.54	„NaCl“	
	Deposition \pm SD			Concentration \pm SD
	[mg/m ² d]		[mg/m ³ d]	[$\mu\text{g}/\text{m}^3$]
Norderey [rural]	8,9 \pm 6,5	10,2 \pm 7,7	2,4 \pm 1,8	39,6 \pm 28,6
Baltrum [rural]	3,4 \pm 2,9	4,1 \pm 3,7	1,1 \pm 0,9	22,8 \pm 17,9
Langeoog [center]	1,9 \pm 2,0	2,3 \pm 2,6	0,6 \pm 0,4	13,9 \pm 10,6
Mainland [kerbside]	0,9 \pm 0,6	1,1 \pm 0,9	0,3 \pm 0,3	6,8 \pm 6,6

Ion chromatographic (total) and microscopic (size fractionated) measurement on ambient air samples collected with the passive sampler Sigma-2.

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