Recent enhancements and new applications of passive sampling of ambient particles - the new VDI guideline 2119

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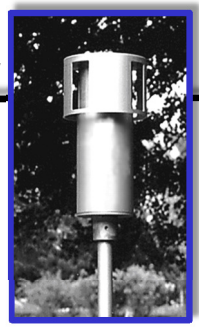
Passive sampling

- Ambient particles are characterized by a growing spatial variability with particle size, resulting in an uncertain estimate of the individual exposure.
- Passive samplers are suited to reduce this uncertainty because of the possibility of denser networks due to the cost-efficient simple technique, and easy use.
- Samples provide fast access to particle properties by light and electron microscopy assumed appropriate sampling media.
- Passive sampling does not need intensive maintenance and requires no energy supply favoring it for remote or observational network studies.

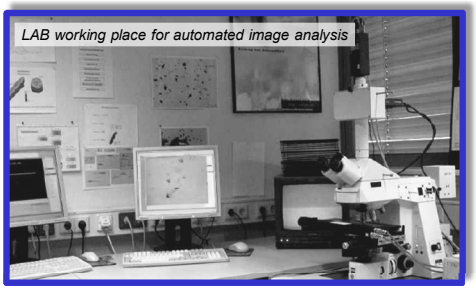


Sigma-2 "in the field"

Opportunities and limitations

Opportunities

- Cost-effective sampling of ambient particles of d_p > 2.5 µm
- Employment of light microscopy for particle characterization
- Discrimination of transparent particles of geogenic and biologic origin, and opaque (black) mostly anthropogenic particles, e.g. fly ash, tire wear
- Suitable for various analytical techniques by choosing adequate deposition media
- Mild sampling conditions without stressing particles mechanically
- Isolated deposition of particles by choosing an appropriate sampling period



LAB working place for automated image analysis

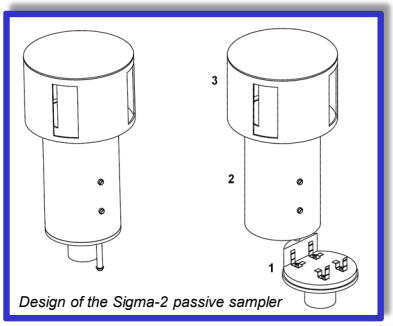
Limitations

- Lower sampling efficiency in comparison to active sampling
- Longer sampling time to obtain an equivalent particle mass
- Complete collection restricted to settling particles of d_p > 1 µm
- Not recognized for air pollution control in Germany
- Not suitable for indoor particle sampling

Design and operation

- Collection of particles from ambient air in a tube covered by a protective cap acting as a sedimentation chamber tube
- Cap equipped each with four vertical inlets providing an exchange of air between the interior and ambient air
- Sedimentation of particles in nearly calm air onto sticky plates suitable for microscopic single particle analysis

The passive sampler was originally designed by the "Institut für Physik der Atmosphäre" of the University of Mainz .
This version was modified by the "Deutscher Wetterdienst" and described under the designation „Sigma-2" (VDI 2119,1997).
Since the late 1980's, the Sigma-2 sampler is in use for the assessment of air quality in German spas by the German Meteorological Service and in world-wide research projects.



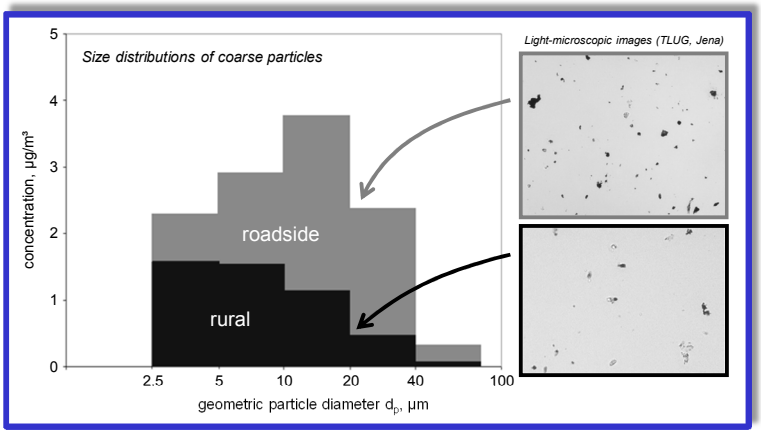
Design of the Sigma-2 passive sampler

Enhancements

Since 1997 the sampling and analysis of collected particles was significantly improved and extended by:

- deploying new collection plates and sample vessels providing the application of more advanced analytical methods,
- developing of specific staining techniques for a separate detection of mineral and biological particles,
- calculating concentration data d_p > 2.5 µm from microscopic analysis of the particle deposit,
- establishing size distributions of coarse particles in the range 2.5 to 80 µm from derived size fractionated particle data.

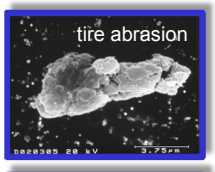
Including these enhancements, a revised version of the VDI guideline 2119 was elaborated by the authors and is expected to be published by the Association of German Engineers VDI next year (VDI 2119, 2011).

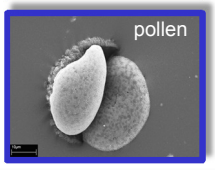


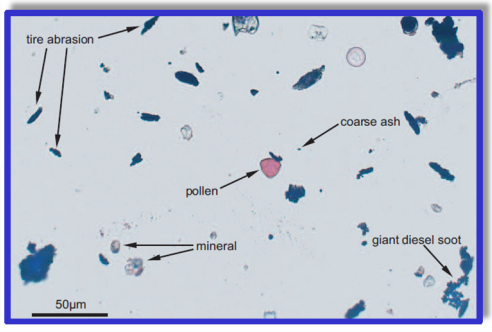
Applications

- Measuring the particle burden in German spas in compliance with licensed requirements.
- Collecting pollen from ambient air for a monitoring of gene-modified organisms.
- Identifying particles of natural origin for an estimate of the natural input to PM10.
- Studying the spatial dispersal of particles for a better estimate of personal exposure.
- Monitoring the particle burden even in extreme remote conditions, e.g. on Greenland.

Light microscopic image of a Sigma-2 sample (DWD Freiburg) with subsequent electron-microscopy of a tire abrasion particle (Rauterberg-Wulff, VDI Berichte Nr. 1228, 1995) and pine tree pollen (KIT Karlsruhe).







The sampler Sigma-2 provides further applications, e.g. source identification by electron-microscopical or µ-synchrotron analysis in remote regions or observational network studies.