Name of research institute or organization:

Institute for Chemical and Bioingeneering, Swiss Federal Institute of Technology, ETH Zurich

Title of project:

Quantitative characterization of the impact of environmental factors on the performance of passive air samplers for semi-volatile organic compounds

Project leader and team:

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Project description:

In this project a novel device for the sampling of semi-volatile organic compounds (SVOCs) in ultra-trace levels at remote sites is evaluated and further developed. Some SVOCs such as polychlorinated biphenyls (PCBs) or polybrominated diphenyl ethers (PBDEs) have been recognized as persistent organic pollutants (POPs). POPs represent environmental contaminants of particular concern because they can affect human health and the environment and are concurrently recalcitrant to degradation, accumulate in human and animal tissue, biomagnify along food chains, and undergo long-range atmospheric transport. SVOCs have appreciable vapor pressures of 10^{-12} – 10^{-2} Pa (at 20°C). Thus, SVOCs are volatile enough to be significantly mobile in the atmosphere, where they partition between the gaseous and particulate phase. Accurate quantification of SVOCs in air samples is very challenging and particularly time, labor and resources intensive. Typical concentrations of PCBs and PBDEs in remote ambient air lie within 0.1 k – 10 pg/m^3. To sample SVOCs in ambient air, active air samplers have been widely used since several decades. This technique entails sucking a predetermined volume of air at a controlled flow rate (typically 500 – 1500 m^3/day) through a sorbent during a certain period of time (typically 12 – 24 hours). Chemicals with a high affinity for the selected sorbent are thereby trapped and can be quantified afterwards in the laboratory. Although active air samplers are widely acknowledged as accurate sampling techniques, they suffer from some relevant drawbacks, in particular their high costs. For sampling in remote places, the required maintenance, the need for power supply and the noise emissions can also be serious limitations.

More recently, passive air samplers have been developed and proved that in many cases they represent suitable alternatives to active air samplers. Passive air samplers consist of a sorbent exposed to ambient air during a longer period of time (typically 4 – 8 weeks). Through passive diffusion of SVOCs from ambient air to the sorbent, the passive sampler accumulates SVOCs that are afterwards extracted and quantified in the laboratory. The main advantages of passive samplers are the low costs, autonomy from power supply, easy use, and complete absence of noise emissions. However, passive samplers have also limitations, particularly the longer sampling period necessary for the sufficient accumulation of SVOCs to overcome analytical detection limits. Typical air sampling rates are 1 – 5 m^3/day. Furthermore, the volume of air sampled by the passive sampler is difficult to control, limiting seriously the accurate determination of air concentrations of SVOCs.

Thus, in studies where active samplers are not available or impossible to use, but where higher temporal resolution of sampling is still essential, an additional sampling

technique is required. Therefore, flow through air samplers have recently been developed by Xiao and coworkers in the group of Frank Wania at the University of Toronto at Scarborough, Canada. These new samplers allow increased sampling rates by forcing the wind through the sampler, which consists of a horizontally oriented, aerodynamically shaped flow tube and turns into the wind with the help of vanes (Figure 1). A series of polyurethane foam discs with relatively large porosity mounted inside the flow tube serve as the sorbent. The sampled air volume is calculated from wind speed measured outside the sampler. The first flow through samplers developed by Xiao and coworkers have been tested under typical wind speed conditions (e.g. 1 – 10 km/h) and allowed sampling rates of *ca.* 100 m^3/day, which is approaching the sampling rates of conventional active air samplers.

The goal of this project consists in testing the original flow through samplers at the High Alpine Research Station Jungfraujoch. The original samplers have been developed for normal atmospheric conditions, whereas Jungfraujoch represents much more extreme conditions. The observation of the performance of flow through samplers under the particular conditions of Jungfraujoch provides valuable information for their further use in remote mountain sites.

The original flow through sampler was installed at the terrace of the Sphinx observatory during six months (Figure 1). The original sampler proofed to be suited for the strong wind speeds prevailing at Jungfraujoch (typically 10 – 100 km/h with peaks of up to 180 km/h). However, the rapid formation of ice around the sampler revealed to be a major obstacle. Regularly, ice clogged the sorbent and hindered the rotation of the sampler.

Figure 1. *Picture of the original flow through air sampler installed at Jungfraujoch (picture Matthew MacLeod, Stockholm University).*

Based on the valuable observations at Jungfraujoch, a new version of the original flow through sampler has been developed at ETH Zurich. The new sampler was completely redesigned and reconstructed with high-grade materials. A three module heating system intended to prevent ice formation on the sampler has been integrated into the flow tube, sorbent casing, and articulated joint.

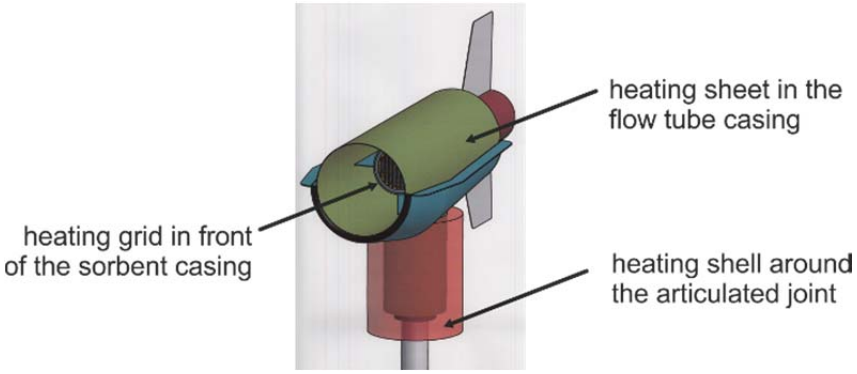

***Figure 2**. Sketch of the newly constructed flow through air sampler.*

Currently the new version of the flow through sampler is tested at ETH Zurich. As soon as this first performance test confirms the preliminary positive results, the new flow through sampler will be installed at Jungfraujoch for an evaluation under real field conditions. On a mid-term, the continuous operation of the new flow through sampler at Jungfraujoch is planned with the objective to study temporal variations of SVOCs.

Key words:

semi-volatile organic compounds, persistent organic pollutants, air monitoring, passive air sampling

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