Indoor Air Quality Monitoring at an Industrial Facility

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The vast majority of people spend most of their time indoors, either at work or at home. Indoor air quality is therefore of high importance as it affects people's health, comfort, and work performance. In indoor air, thousands of volatile organic compounds (VOCs) are present. They are emitted largely by construction materials, volatile chemical products usage, or industrial processes [1]. Due to the large wall surface area, building insulation and/or non-sufficient building ventilation, VOCs can accumulate and adversely affect health or contaminate sensitive working environments. The World Health Organization considers air pollution, including indoor air, as one of the top five risks to public health [2].

Real-time monitoring of VOCs is essential to evaluate and control human exposure to potentially dangerous levels of indoor air contaminants, and to improve poor indoor air quality by better understanding and identifying the pollutant sources.

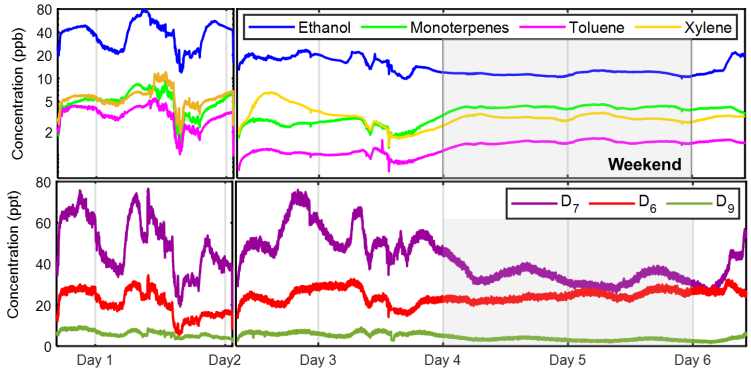

Figure 1 *PTR-mode measurement of ethanol, monoterpenes, toluene, and xylene (top panel) and several cyclosiloxanes (bottom panel) over a period of a week in an industrial facility*

Real Time Measurement of Indoor VOCs by Vocus CI-TOF

The Vocus CI-TOF is fast, sensitive, and robust instrument able to simultaneously monitor hundreds of VOCs in the air at sub ppb concentration. The high resolving power of the TOF mass spectrometer together with various soft ionization modes provide accurate identification of targeted species. As the air is measured directly, no sample preparation is required, in contrast to commonly used sorbent tube GC-MS sampling, which is much slower, offline, and requires sample preparation.

In order to monitor the time evolution of the indoor air species present in a working environment, the instrument was placed in the TOFWERK R&D and production facility for two weeks. The instrument was operated in both traditional proton transfer reaction (PTR) mode and in NH_4^+ mode which allows for less fragmentation and targets more oxygenated species.

An example of PTR measurement of selected common indoor air pollutants is shown in Figure 1. The 24h patterns in the concentration, with higher concentrations during the day and lower concentrations at night, can be linked to the industrial activity and working hours. During the weekend, the concentration is reduced by factor 2-5. In Figure 2 a mass spectrum of indoor air measured by the Vocus CI-TOF in NH_4^+ mode is shown. Hundreds of species are detected simultaneously ranging over three orders of magnitude in concentration. A clear pattern of siloxanes observed up to 900 m/Q is highlighted. Even D12 siloxane ($C_{24}H_{72}O_{12}Si_{12}$) was able to be measured quantitatively with an average mixing ratio of a few ppt. Siloxanes are highly stable and volatile chemicals that

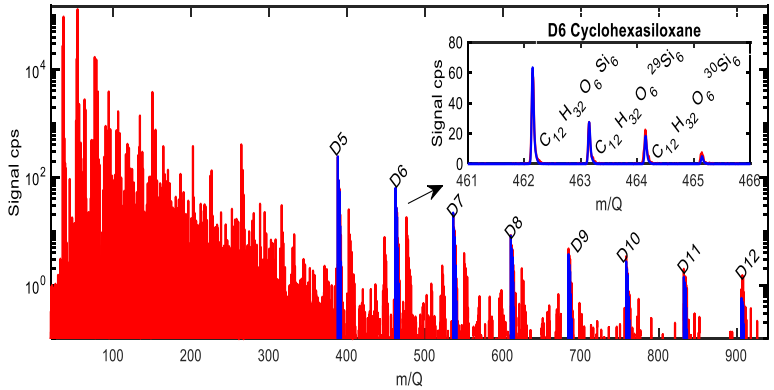

Figure 2 *Mass spectrum of indoor air measured by the Vocus CI-TOF in NH_4^+mode. Series of siloxanes commonly present in an industrial environment are highlighted blue.*

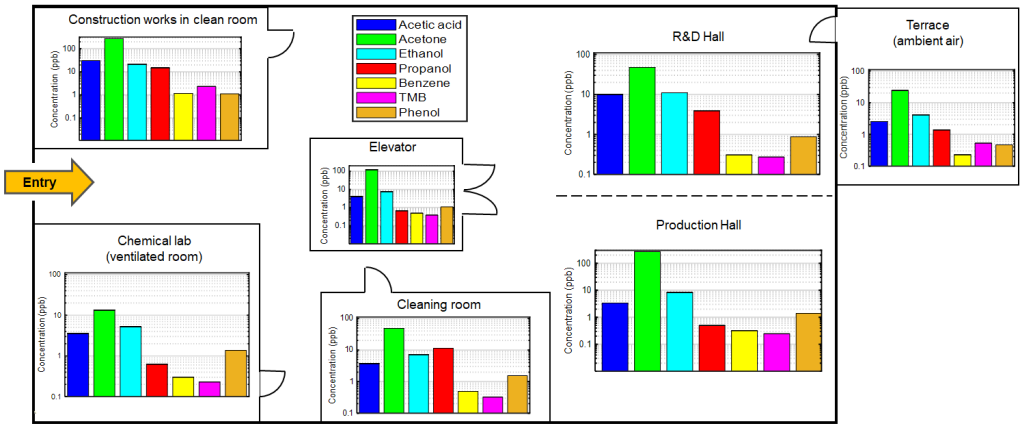

Figure 3 *Concentration of selected VOCs on a log scale measured during mobile measurement in six separated industrial areas*

are additive ingredients widely used in plastics, lubricants, oils and cosmetics. The most intense siloxane observed was dodecamethylcylcopentasiloxane (D5) which is a common compound found in urban air and associated with personal care products [3]. As Vocus CI-TOF measures the whole mass spectrum simultaneously, the specific isotope pattern of siloxanes can be used to confirm their elemental composition.

Mobile Indoor Measurement

Because the instrument is portable, the VOC levels in various indoor areas can be investigated within a short period of time. Such measurement can provide useful information on possible leakage or contamination. Figure 3 shows the results of mobile measurement performed with the Vocus in different parts of the industrial hall within 30 minutes.

The concentrations are shown on a log scale and can vary by factor of 5 -10 depending on the area being measured. The rooms with active ventilation (e.g. Chemical lab) showed lowest VOC levels which were comparable to ambient air. The cleaning room showed high levels of propanol coming presumably from the cleaning and disinfectant chemicals stored inside. The highest concentration of VOCs in general was measured in the clean room where construction and painting works were in progress.

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References

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[2] World Health Organization, “Ten threats to global health in 2019”, Newsroom Feature Stories, https://www.who.int/news-room/feature-stories/ten-threats-to-global-health-in-2019, date of last access 7 May 2020.

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