THE MOBILE SIFT-MS LABORATORY

PART 2: POLLUTION SOURCE IDENTIFICATION

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ABSTRACT

Tracing volatile pollutants back to their emission source can be difficult in industrial parks. By utilizing a combination of fenceline monitoring with a mobile laboratory equipped with selected ion flow tube mass spectrometry (SIFT-MS) instrumentation together with drone sampling, individual emission sources can be sampled and analyzed rapidly on site. Using an example from the Republic of Korea (South Korea), this application note illustrates the effectiveness of onsite broad-spectrum, high-specificity SIFT-MS analysis combined with drone sampling in the identification of pollution sources.

INTRODUCTION

Utilization of SIFT-MS mobile laboratories for characterization of volatile organic pollutants in industrial complexes was described in Part 1, both for stationary and on-the-move monitoring. Such monitoring is necessary because it identifies the volatile organic compound (VOC) emissions associated with specific localities in the complex and which may need to be targeted during a pollution incident. On such occasions, it is important that the specific source of pollution is important for resolving the pollution issue as quickly as possible and holding those responsible for it accountable.

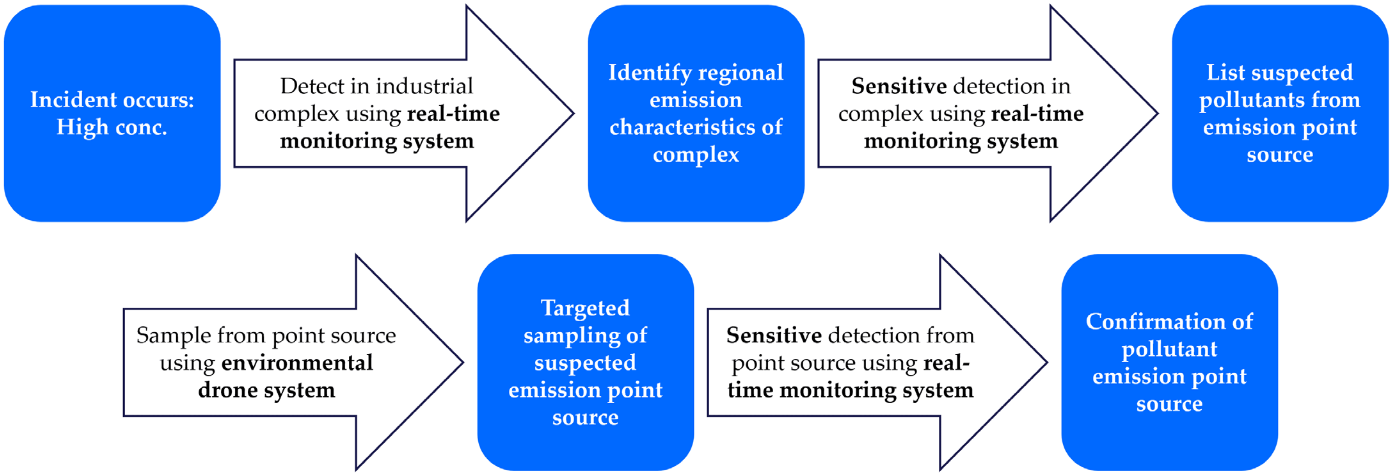
Given the transient nature of many incidents, it can be difficult to identify the source of pollutants using conventional approaches involving time-averaged sampling at site and analysis at an off-site laboratory. Moreover, in high-density industrial complexes, there may be many potential sources for the pollutant(s). Feedback is necessarily slow when utilizing regulatory chromatographic methods.

In contrast, rapid screening of potential pollution sources can be conducted using drone sampling and SIFT-MS once the hotspot has been identified using on-the-move SIFT-MS mobile monitoring (if it is not known already). The full incident workflow proposed originally by the South Korean National Institute of Environmental Research (NIER; Ryu *et al*. (2019)), which combines mobile SIFT-MS monitoring and drone sampling, is shown in Figure 1. The flexibility of sample introduction with SIFT-MS enables grab samples collected by drone to be analyzed immediately on site in the mobile laboratory. Once the pollution source is identified, a sample can be collected for regulatory analysis in an accredited laboratory. Meanwhile, the polluting organization can be notified immediately and actions implemented to address the pollution issue.

This application note demonstrates the use of complementary SIFT-MS mobile laboratory and drone sampling approaches that provide effective incident response.

It uses a case study from South Korea, a highly industrialized nation with many high-density industrial parks.

Figure 1. Schematic overview of the NIER pollution incident workflow using a real-time monitoring system (SIFT-MS) and drone sampling (Ryu et al (2019)). Reproduced from Langford et al. (2023) under the terms and conditions of the Creative Commons Attribution (CC BY 4.0) license (https://creativecommons.org/licenses/by/4.0/)).



METHODS

The principles of the SIFT-MS technique and the components of the mobile SIFT-MS laboratory solution are described briefly in Part 1.

Drone sampling is readily conducted using a commercially available drone (Matrice 600 Pro; Scentroid, Toronto, Canada) and associated sampler (DR1000; Scentroid). This drone model has a sample capture system and up to five user-selectable sensors can be installed for in-flight monitoring. Data can be monitored in real time through communication with ground receivers. The collection function can also be operated remotely, enabling an installed Tedlar® sample bag to be filled in flight if sensors detect elevated concentrations. The filled sample bag is immediately analyzed at the collection location using the SIFT-MS instrument in the mobile laboratory. On-site SIFT-MS analysis within minutes of sampling eliminates sample degradation and gives immediate, quantitative feedback on the emission source.

RESULTS AND DISCUSSION

Shin *et al.* (2020) used real-time SIFT-MS measurement and subsequent drone sampling from suspected emission sources at nine locations in the Banwol National Industrial Complex in Ansan, northwest South Korea. They targeted 11 chemically diverse hazardous air pollutants (HAPs) and odor compounds in a single SIFT-MS method (benzene, toluene, ethyl benzene plus xylenes, styrene, 1,3-butadiene, propanoic acid, methyl ethyl ketone (MEK), acrolein, hydrogen sulfide, trichloroethylene, and tetrachloroethylene). The study approach is summarized in Figure 2. First, a SIFT-MS-equipped mobile laboratory was used to acquire data at nine locations in the complex to determine fenceline concentrations of pollutants. Second, three areas with suspected higher pollutant concentrations were subjected to more intensive survey (see Figure 3). Finally, drone sampling was conducted to identify the sources of pollutants.

Figure 2. The combined real-time SIFT-MS monitoring system and drone sampling approach used by Shin et al. (2020). Used with permission.

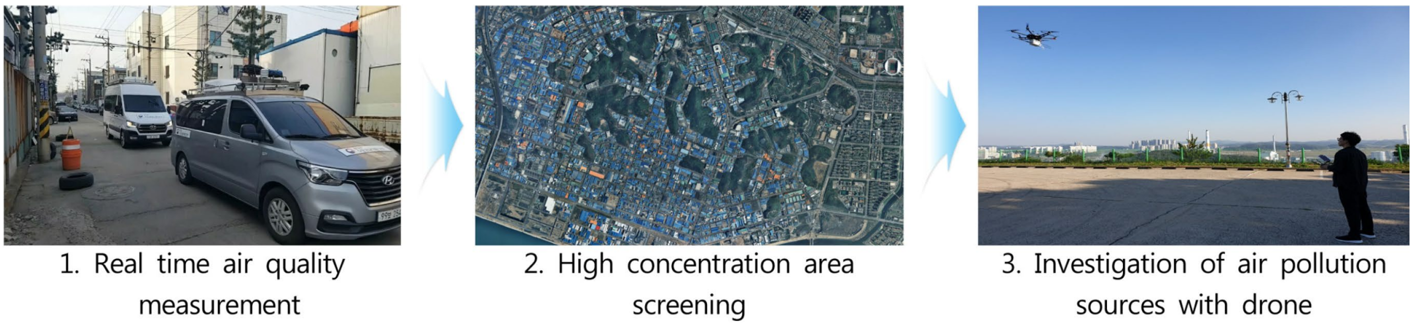
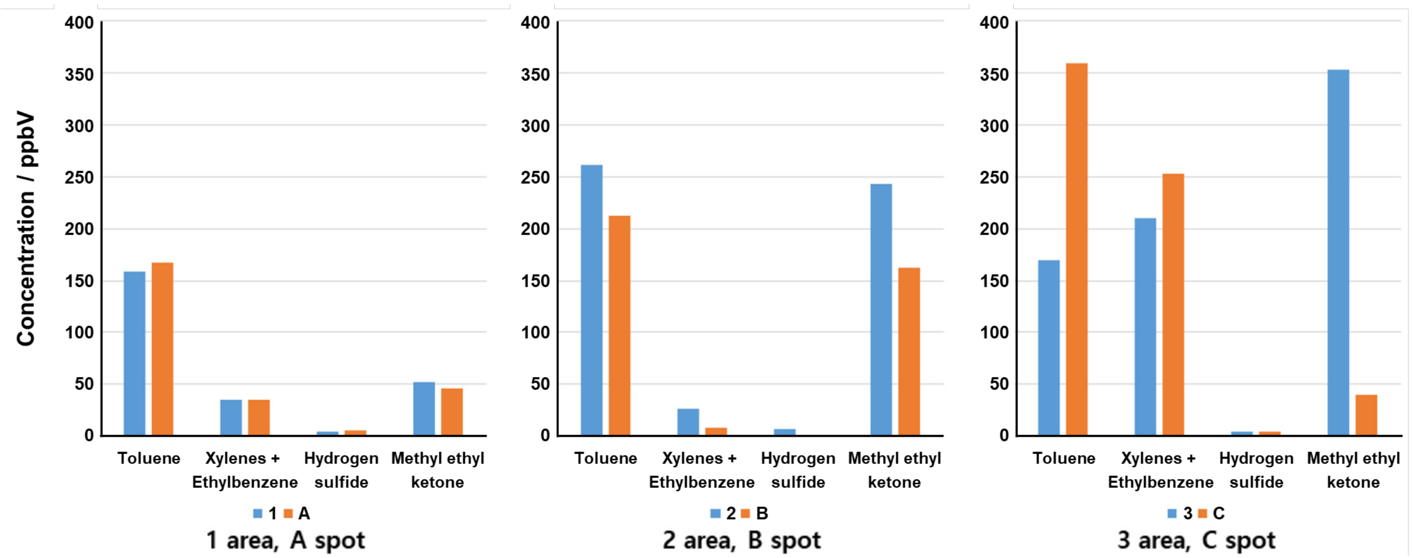


Figure 3. Areas 1, 2, and 3 – with suspected higher concentrations of VOC pollutants – were monitored using a fenceline approach. Drones sampled sources at points A, B, and C (Shin et al. (2020)). Used with permission.

Figure 4 shows comparative results obtained for fenceline and drone sampling at locations A, B, and C in higher concentration areas 1, 2, and 3, respectively (Figure 3).

The concentrations of toluene, xylene, hydrogen sulfide, and MEK were much higher than background measurements at these sites. Based on the general agreement between the fenceline and drone samples, Shin *et al.* (2020) concluded that the use of drone and real-time SIFT-MS monitoring enables rapid identification of pollutant sources.

Figure 4. Concentrations measured using SIFT-MS for fenceline monitoring (1,2, and 3) and drone samples (A, B, and C) (Shin et al. (2020)). Adapted with permission.



Note that the complementarity of drone sampling and the mobile SIFT-MS laboratory is not limited to pollution response (Langford *et al.* (2023)). Drone sampling can be utilized in research, since it enables altitude dependence to be studied (Choi *et al.* (2022)) – an important consideration in dispersal of pollutants since hazardous and odorous VOC emissions from industry can disperse far beyond the fenceline.

CONCLUSIONS

- High-sensitivity, broad-spectrum analysis of volatile pollutants.
- Robust SIFT-MS technology with field-proven deployment in mobile laboratories, collecting data even while moving.
- Effective event response through on-the-move monitoring and analysis of grab samples on-site.
- Ideally paired with drone sampling for pinpointing emission sources.
- Instant on-site decision-making with rapid, specific gas analysis in continuous monitoring and sample bag analysis modes.

ACKNOWLEDGEMENT

We gratefully acknowledge Dr Shin and his colleagues for permission to reproduce and adapt figures in this case study.

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