Development of Cost Effective Fence Line Monitoring Approaches to Support Advanced Leak Detection and Repair Strategies

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William C. Squier[1], William A. Mitchell[1], Eben D. Thoma[1], M. Shahrooz Amin[2], and Mark T. Modrak[2]

[1] U.S. EPA, Office of Research and Development, National Risk Management Research Laboratory, 109 TW Alexander Drive, E343-02, Research Triangle Park, NC 27711,

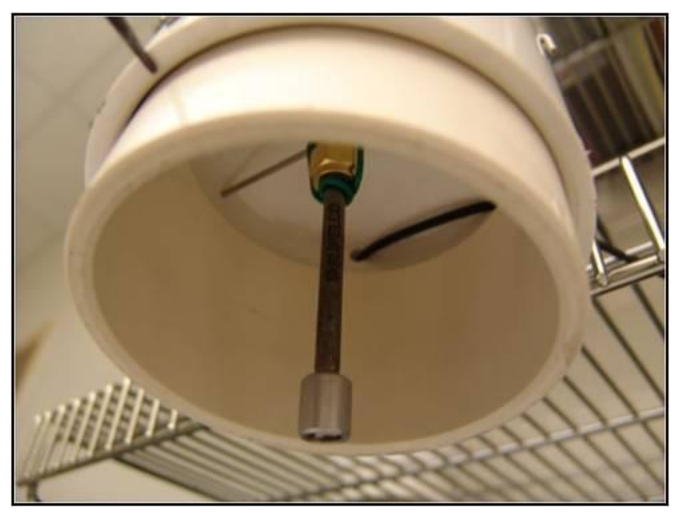
[2] ARCADIS Inc., 4915 Prospectus Drive, Suite F, Research Triangle Park, NC 27713, USA

Purpose

Cost-effective fenceline and process monitoring systems to support advanced leak detection and repair (LDAR) strategies can enhance protection of public health, facilitate worker safety, and help companies realize cost savings by reducing lost product. The U.S. EPA Office of Research and Development (ORD) is working to develop a variety of next-generation fenceline monitoring approaches ranging from time-integrated passive sampling to time-resolved concentration and wind field measurements. This poster presentation summarizes development progress on several low-cost fence line monitoring systems.

Passive Samplers

Passive Sampling Absorption Tube in a Protective Hood



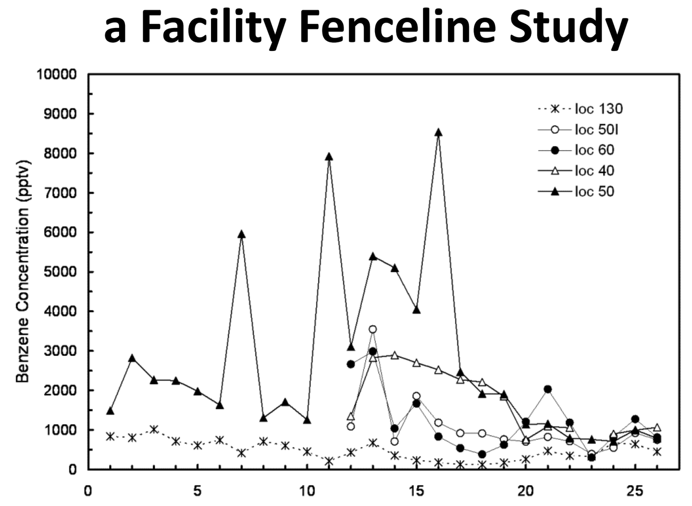
Passive diffusive tube samplers provide a low cost, easy-to-deploy way of determining time-averaged fenceline concentrations for many species. The samplers are hung under protective hoods around a facility and are replaced every 2 weeks. Passive samplers provide a useful screening tool to determine areas that may need further LDAR investigation.

Advantages:
- Easy to deploy / low training requirements
- No power required
- Low cost for sampler and analysis (≈ $50 single compound)
- Large range of VOCs compounds can be measured
- Can be used on fenceline or in the facility
- Time-integrated: provides a long-term measure of concentrations
- Flexible deployment (one day to one month integration times)

Disadvantages:
- Limited source identification capability :

For long time-duration deployments in areas with mixed wind directions and upwind sources, difficult to pin point sources

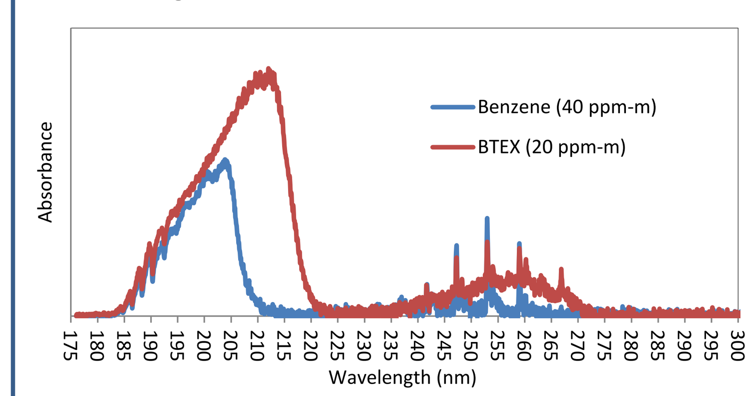
Passive Sampling Results from a Facility Fenceline Study



Two-week time-averaged benzene results taken over a one year period at upwind (loc 130) and downwind locations on a refinery fenceline. With steady wind conditions, passive samplers can identify areas for targeted LDAR investigations with more detailed measurements.[1]

Deep Ultraviolet Optical Sensors (DUVOS)

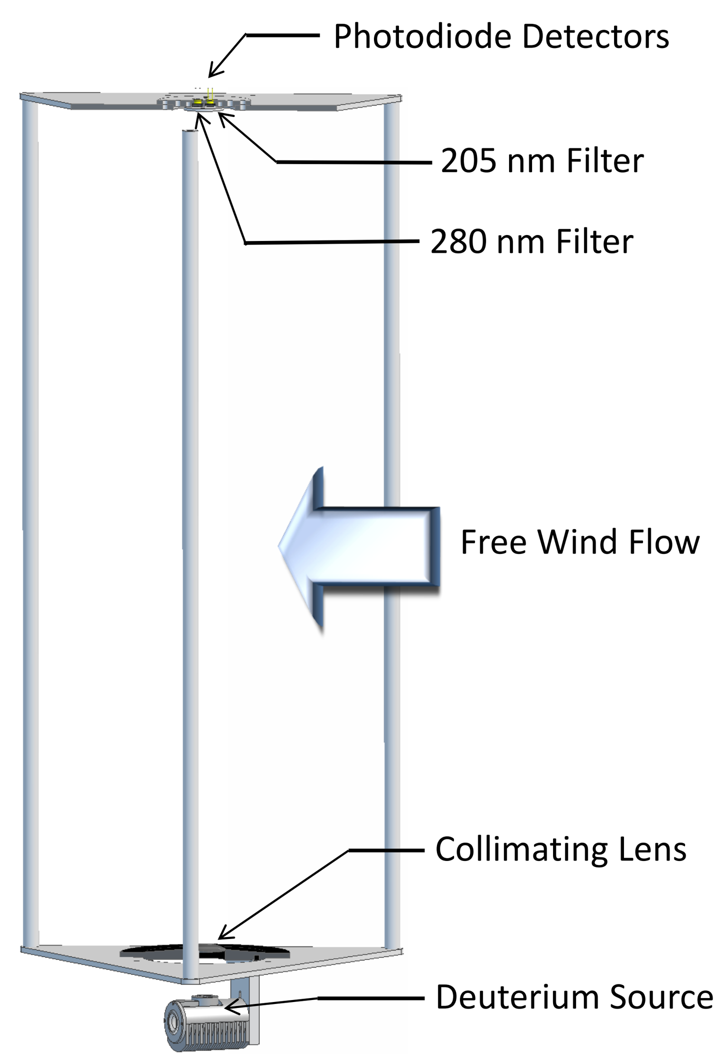
Deep UV Absorbance of BTEX



The figure at the left shows the deep UV absorption characteristics of benzene and of a mixture of equal parts benzene, toluene, ethyl benzene, and xylene (BTEX). Typical speciating instruments must integrate the area under a small spike (such as the benzene spike seen at 253 nm) using spectrometers and computer software. The large benzene response seen at 205 nm can be detected using a 205nm bandpass filter and a photodiode or photomultiplier tube giving an integration under a much higher and broader curve. An on band (205 nm) / off band (280nm) ratio between two detectors blocks interferences like particulate that are not absorption features. This allows non-speciated detection of BTEX compounds with a voltage ratio output requiring no computer processing using simple photodiodes or photomultiplier tubes.

DUVOS Point Monitor

Section View of an Open Cell DUVOS Point Monitor



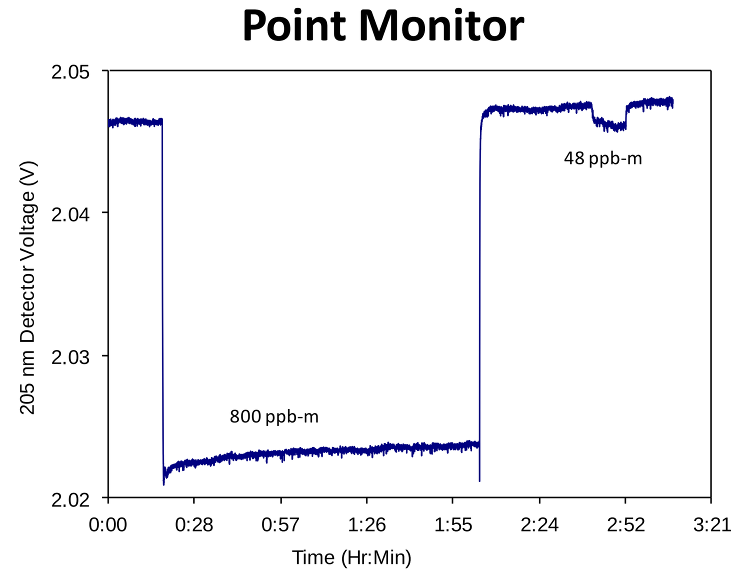
DUVOS point monitor can support LDAR programs by identifying leaks and locating leaks as they occur though fenceline observation.

Advantages:
- High detection sensitivity (ppb level)
- Simple design, low cost (< $5k)
- Open cage design (free wind flow)
- Source ID by concentration, wind correlation
- Trigger canister for speciation analysis
- Solar powered (easy deployment)
- Emission rate estimates (in-development)

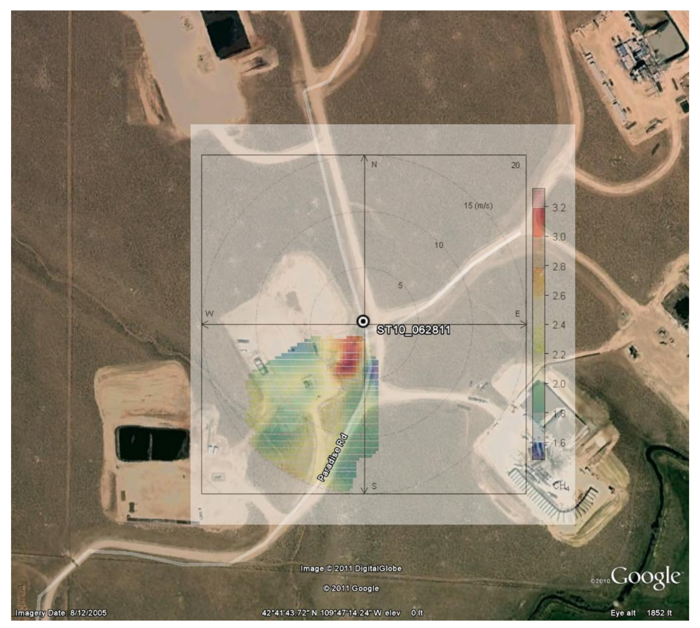
Disadvantages:
- Nonspeciating measurement
- Can not measure alkanes
- Interferences are possible (NH_3, SO_2, H_2S)

Although the DUVOS responds to a range of compounds, the concentration temporal signature can be used to identify source

Benzene Response of a DUVOS Point Monitor



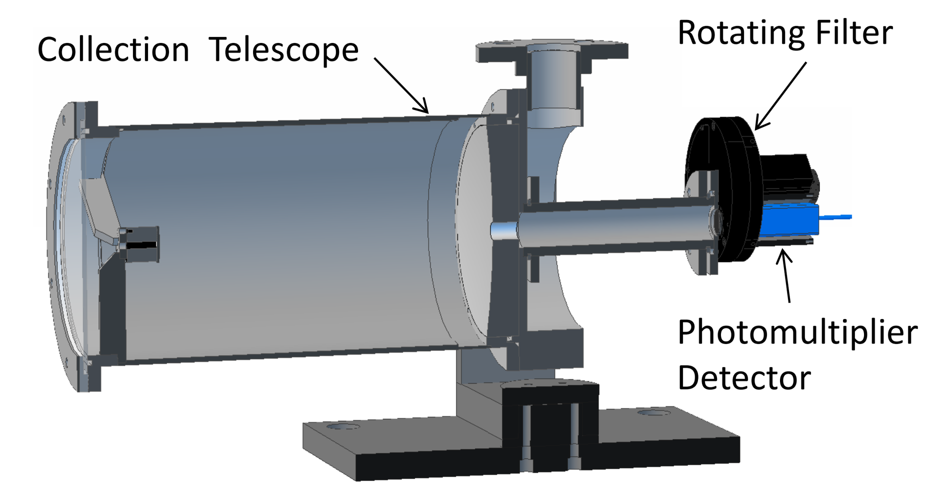
Combined 10 Hz Detector and Wind Data Polar Plot



- R axis is wind speed.
- Θ axis is wind direction.
- Color is detector response

DUVOS Open Path Monitor

Section View of an Open Path DUVOS Receiver

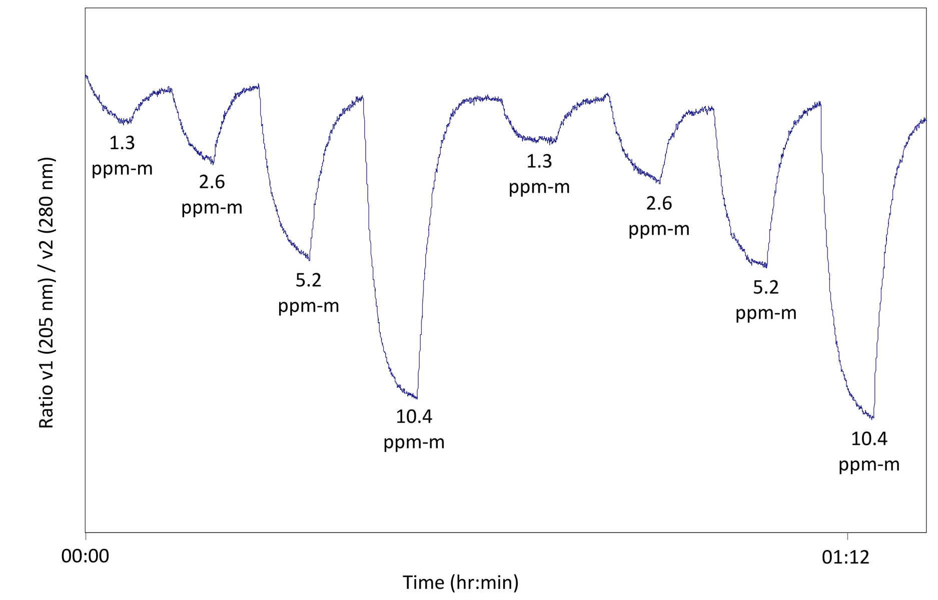


DUVOS open-path monitor can cover large areas of a facility fenceline and provide alarms to LDAR crews.[2] Uses telescopes for projecting optical beams and an alternating 205/280 nm rotating filter for detection.

Advantages:
- Long open-path observation (> 500 m))
- A few units can cover entire fenceline
- Low cost compared to speciating spectrometers

Disadvantages:
- Need power and permanent mounts

BTEX Response of an Open Path DUVOS System



Mobile Methods

Geospatial Mapping of Air Pollutants (GMAP) Vehicles

U.S. EPA as well as private companies are developing a mobile assessment approaches that allow for drive-by inspection of potential sources from remote vantage points. These approaches are part of EPA's Geospatial Measurement of Air Pollution (GMAP) program which uses fast-response instruments and a precise global positioning system in a mobile platform to map air pollution patterns in areas around sources.

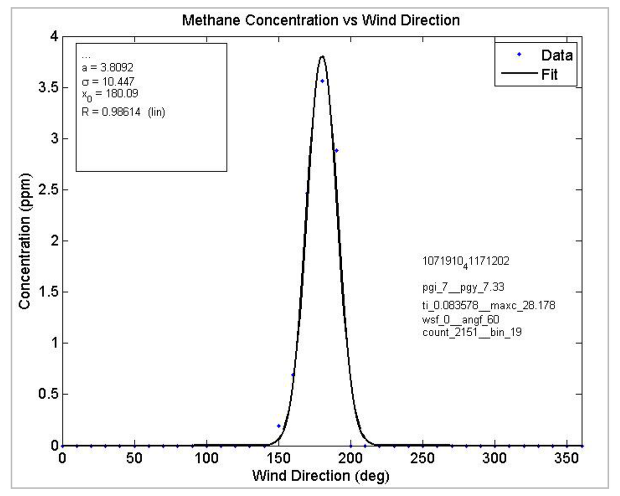
- EPA ORD: High speed (10 hz) CH_4 cavity ring down system (CRDS)
- EPA R5: CH_4 and H_2S CRDS (0.5 Hz)
- Waste Management : CH_4 and C_2H_2 tracer correlation system
- EPA NEIC: High speed CH_4 and UV BTEX analyzers

All the vehicles are equipped with a compact auto north weather stations, 3D sonic anemometers, high resolution GPS, battery power systems, and canister sampling.

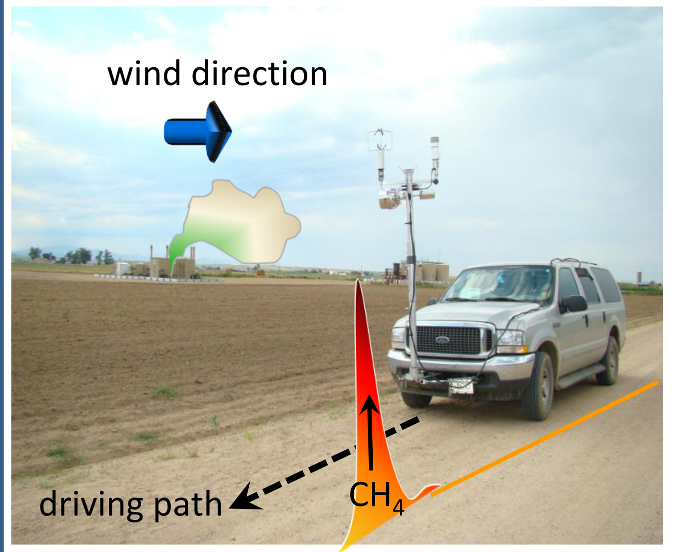
Advantages:
- Cover large areas
- Locate and estimate emissions
- Remote application
- Canister speciation

Disadvantages:
- Need wind to transport plume
- Need down-wind road access
- Need few obstructions (free flow)

CH_4 vs. Wind Direction



GMAP Vehicle Operation



Using high speed (2-10 Hz) time aligned concentration and wind data taken by the GMAP vehicle while parked downwind of a source concentration is binned as a function of wind angle. The result is a Gaussian curve that can be used to estimate source emissions.[3]

References: 1. Thoma, E.D.; Miller, M.C.; Chung, K.C.; Parsons, N.L.; Shine, B.C. 2011. *Facility Fenceline Monitoring using Passive Sampling*, J. Air & Waste Manage Assoc. 61:834-842. 2. Mitchell, B.A.; Thoma, E.D.; Squier, B.C; Secrest, C. *Simplified and Low Cost Optical Remote Sensing Technology for Fence Line Monitoring of Fugitive Releases*, Proceedings of 103rd Annual Conference of the Air & Waste Management Association, June 22-25, 2010, Calgary, Alberta, Canada. 3. Thoma, E.D.; Squier, B.C.; Olson, D.; Eisele, A.P.; DeWees, J.M.; Segall, R.R.; Amin, M. S.; Modrak, M.T. *Assessment of Methane and VOC Emissions from Select Upstream Oil and Gas Production Operations Using Remote Measurements, Interim Report on Recent Survey Studies*, Proceedings of 105thAnnual Conference of the Air & Waste Management Association, 2011-A-21-AWMA, June 19-22, 2012, San Antonio, Texas.