Field test evaluation of instrumental odour monitoring systems with a novel in-situ calibration approach

Practical evaluation of the CEN/TC 264/WG 41 method

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3S – Sensors, Signal Processing Systems GmbH

Company Overview

est. 2006
30 employees

- Experts in gas measurement
  - Leakage detection and odour assessment for industry and production
  - Indoor and outdoor air quality monitoring
  - Development of white label products: “Gas sensing solutions”

- Production and calibration of own and OEM products
Project context
IOMS development and field tests

- **SEPEG**
  - Sensor networks for objectified odour perception
  - Funded by the German Federal Ministry of Education and Research (FKZ 01IS1)
  - Partners: 3S, Saarland University, Olfasense

- **Goals**
  - Development of a sensor system for odours that is suitable for calibration
    ⇒ **IOMS** = instrumental odour monitoring system
  - Development and test of calibration strategies

- **Field test sites**
  - Industrial site
    → Odour impact monitoring in nearby residential area (8 devices)
  - Wastewater treatment plant
    → On-site monitoring of odour occurrences (4 devices)
Robust enclosures for outdoors and public sites

Pumped sampling with gas path switching
- e.g. ambient / calibration / zero reference
- e.g. A / B / zero reference (filter monitoring)

Modular concept for
- Metal oxide sensors (VOCs, H2, CO, ...)
- PID (TVOC)
- EC cells (NH3, H2S, NO2, O3, ...)
- ext: PM1.0/2.5/10, CO2, rH, T, p

Real-time online monitoring, data transport via LTE or ethernet, incl. geoposition

Connectivity for local weather station

UPS integration (solar, streetlight)
CEN/TC 264/WG 41 aims at

- Standard for **validation** of technical odour monitoring systems
  - Term IOMS = instrumental odour monitoring system
- Use cases: Absence/Presence, identification, quantification
- Prepared (diluted) source samples, allowing for predictable “occurrence” of target odours

Manufacturer’s claim

- Form confidence level and confidence interval
- Basis for validation: **Representative** set of sample pairs (absence / presence)
- Minimum requirement: 8 (9) pairs → Evaluation using Chebychev’s inequality

Consequence for IOMS manufacturers

- No **training** methods or requirements are given → Mfg’s responsibility, black-box-approach
- General idea: Similar calibration rules for training and validation allow for comparability
Calibration strategy
Field evaluation of calibration strategy

1. Source sampling
2. Olfactometry (source odour concentration)
3. Background sampling
4. Direct evaluation (absence of target odour)
5. Splitting into \( n \) secondary sample bags
6. Injection of pre-calculated source sample volume into \( n-1 \) secondary sample bags
7. Direct evaluation (presence of target odour)
8. Application to IOMSs
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**Calibration timetable**

**Field evaluation of calibration strategy**

- Dilution series per source sample
  - 0, 5, (10), 25, 50, 100, (200) OU\_e/m³

- Two teams in offset shifts
  - Sampling and sample preparation
  - Application to IOMSs

- Throughput per day
  - 3 sample sets for 8-device-installation
  - 6 sample sets for 4-device-installation

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<th>Uhrzeit</th>
<th>Sample 1</th>
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Results
From a calibration point of view

- Odour prediction
  - Training works better for industrial emission than for waste water (less source variation)
  - Validation result $x = 15.5 \text{ @ } \alpha = 30\%$
    (Dynamic olfactometry: $x = 4 \text{ @ } \alpha = 5\%$)
  - Comparability with grid inspection challenging for impact site monitoring
    (more background variation)

- Bag sampling and preparation method
  - Time consuming and expensive
  - Problem with sample bag zero-offset found, not solved yet

- Calibratable sensor system available with corresponding infrastructure
Revisiting the sample bag method
- How to deal with strong background variation?
- How to deal with zero offset in sample preparation?
- Which role plays comparability to grid inspection?

Consequences for manufacturers
- Training method and effort have to be aligned to validation standard
  - Additional data needed for training, more than for evaluation (cost!)
  - Pre-training “out of the box” aka factory calibration
  - Reduction to sure-fire applications? (Emission + dispersion instead of impact site?)
- Cost model for training and validation
  - Three campaigns about as expensive as a one-year EN 16841-1 grid inspection!
  - Only feasible for customers with own olfactometry capacity?
Thanks for your attention

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