Analysis of Sampling Protocols for the EPA Animal Feeding Operations Consent Agreement

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Consent Agreement

• Two-year, nationwide air emission monitoring study

• Determine compliance of AFOs with the CAA, CERCLA, and EPCRA

• Determine emission rates of specified air pollutants from AFOs
## Consent Agreement

<table>
<thead>
<tr>
<th>Animal</th>
<th>Facility</th>
<th>Pollutants to be Monitored</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swine</td>
<td>Mechanically Ventilated Barns</td>
<td>NH₃, H₂S, CO₂, TSP, PM₂.₅, PM₃.₀, VOC</td>
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<td></td>
<td>Lagoons</td>
<td>NH₃, H₂S, VOC</td>
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<tr>
<td>Laying Hens</td>
<td>Mechanically Ventilated Barns</td>
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<tr>
<td>Meat Birds</td>
<td>Mechanically Ventilated Barns</td>
<td>NH₃, H₂S, CO₂, TSP, PM₂.₅, PM₃.₀, VOC</td>
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<td>Open Manure Piles</td>
<td>NH₃, H₂S</td>
</tr>
<tr>
<td>Dairy</td>
<td>Naturally Ventilated Buildings</td>
<td>NH₃, H₂S, CO₂, TSP, PM₂.₅, PM₃.₀, VOC</td>
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<td>Manure Storage Systems</td>
<td>NH₃, H₂S, VOC</td>
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Ammonia Emissions

Mechanically Ventilated Swine, Poultry, and Dairy Barns
- Chemiluminescence
- Photoacoustic Infrared
- Airflow

Manure Storage and Naturally Ventilated Dairy Barns
- FTIR
- UV-DOAS
- Gaussian Modeling
- BLS modeling
Chemiluminescence

Method:
- Oxidizes ammonia to form excited NO$_2$
- Measures radiation emitted during reduction

Pros:
- Sensitivity range from 1 ppb to 500 ppm
- Precision of ±3 ppb

Cons:
- Requires frequent and careful calibration
- Does not usually achieve 100% conversion
- Other chemicals are also converted to NO$_2$
- Cannot measure adsorbed ammonia
Photoacoustic Infrared

Method:
- Measures absorption of infrared radiation

Pros:
- Selectivity and sensitivity can be enhanced
- Detection range down to 20 ppb
- Effects of temperature and pressure are known

Cons:
- Require frequent and careful calibration
- Sensitivity is not isolated to ammonia
- Cannot measure adsorbed ammonia
Airflow

Method:
- Fan Assessment Numeration System (FANS)
- Continuously measure static pressure and fan operational status

Pros:
- Yields in situ airflow measurements
- Accounts for changes in performance with static pressure and use

Cons:
- Static pressure can vary across a building
- Cannot perform FANS test in an occupied building
- Time consuming
FTIR

Method:
• Measures absorption peaks of infrared light
• Interprets peaks using Fourier Transformations

Pros:
• Isolates species of interest
• Detection limit of 1.5 ppb

Cons:
• Requires frequent and careful re-calibration
• Requires costly standard gas mixtures
• Requires an experienced operator to yield good results
UV-DOAS

Method:
• Measures absorption peaks of UV light
• Compares sampled spectra with a calibrated database of calibrated absorption spectra

Pros:
• Corrections for interfering gases are available

Cons:
• Limited effective measurement distance
• Mixed review of data quality
Modeling

Gaussian Modeling
• Used by the USEPA for regulatory purposes
• Assumes normal distribution of pollutants
• Accuracy has long been debated

Lagrangian Stochastic Modeling
• Attempts to determine particle trajectories
• Requires fewer sampled data points

“Cross-model” Issue
When emission factors from WindTrax (bLS model) are used in ISCST3 (a Gaussian model), the modeled concentrations are approximately 10 times the measured concentrations (Price et al, 2004)
PM Emissions

Mechanically Ventilated Swine and Poultry Facilities
- TSP – Isokinetic Multipoint Gravimetric Samplers
- PM$_{10}$ – TEOMs with PM$_{10}$ pre-collectors
- PM$_{2.5}$ – FRM PM$_{2.5}$ Sampler (for at least one month)

Dairy Facilities
- Little specific protocol
- “particle samplers located with a sampling height of 5m”
TSP Emissions

Sampling

- Isokinetic multipoint gravimetric samplers
- No detail is given on the filter media to be used

Analysis

- No detail is given
PM$_{10}$ Emissions

Method:
- TEOMs with PM$_{10}$ pre-collectors

Pros:
- USEPA equivalent method
- Continuous monitoring

Cons:
- Uncertainties with airflow measurements
- Significant differences between TEOM and gravimetric sampling concentration data
- Over sampling bias of PM$_{10}$ pre-collectors in agricultural environments
PM$_{2.5}$ Emissions

Method:
- Gravimetric FRM sampler
- Monitored for at least one month per site

Pros:
- Insufficient details are available

Cons:
- Over sampling bias of PM$_{2.5}$ pre-collectors in agricultural environments
- Limited sampling times will not allow for measurement of temporal variations
Conclusions

• Amendments should be made to the Consent Agreement’s sampling protocol to address deficiencies in the current plan and quantify uncertainties associated with measured and calculated values.

• Data and emission factors derived from sampling under the Consent Agreement should be used cautiously and applied only with an understanding of the limitations of the sampling protocol.