Draft Emission Models for Swine Animal Feeding Operations

October 29, 2020

Introduction

- On August 20, 2020, EPA posted draft emission models for animal feeding operations (AFOs) raising swine.
- These draft emission models utilize data collected as part of the National Air Emissions Monitoring Study (NAEMS).
- The emission models provide methods for estimating air emissions of NH_3, H_2S, and PM (TSP, PM_{10}, $PM_{2.5}$) from barns, lagoons, and basins at swine operations throughout the country.
- EPA developed approximately 30 emission models for the various emission source and pollutant combinations at swine operations.

Outline

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Background – AFO Air Compliance Agreement (Agreement)

- In 2005, the voluntary Agreement, which includes NAEMS, was initiated in response to a National Academy of Sciences report on the complexity of estimating AFOs' emissions from and industry's concern with ongoing EPA and citizen enforcement activity.
- The Agreement's goals were to:
  - (1) reduce air pollution;
  - (2) monitor AFO emissions;
  - (3) promote a national consensus on emission models; and
  - (4) ensure compliance with requirements of the Clean Air Act (CAA), as well as certain reporting requirements under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), and the Emergency Planning and Community Right-to-Know Act (EPCRA).

Air Compliance Agreement

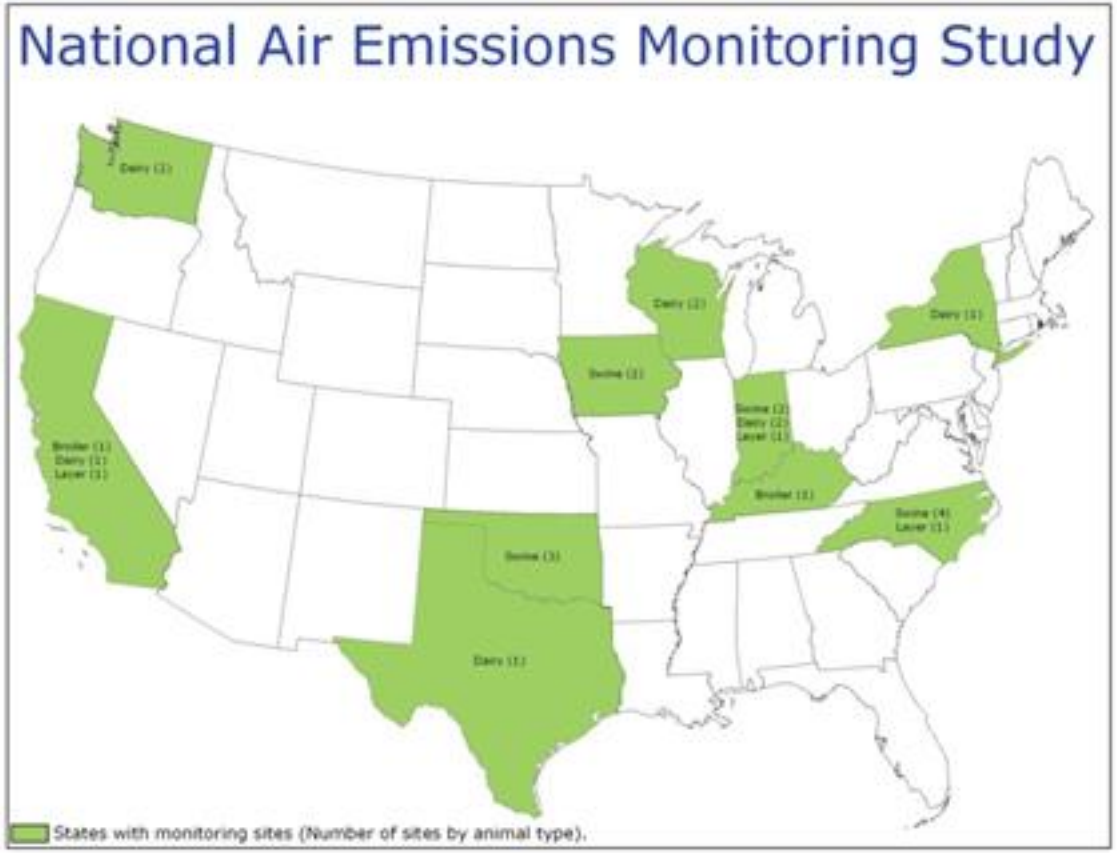
- EPA approved approximately 2,600 Agreements, representing nearly 14,000 participating AFOs.
- Participants paid a civil penalty of between $200 and $100,000, based on the size and number of facilities covered by their Agreement. They also were responsible for contributing to a fund to cover the cost of NAEMS.
- As part of the Agreement, EPA agreed not to sue participating AFOs for certain past and ongoing violations of the CAA, CERCLA, and EPCRA during NAEMS, provided that the AFOs comply with the Agreement's conditions.
- Once EPA publishes final emission models for an AFO's animal sector, that AFO must apply the final models to determine what actions, if any, it must take to comply with any applicable CAA requirements.

Agreement Compliance Requirements

- If the emission models demonstrate that a source does not trigger any CAA permitting requirements, the source must certify this outcome to the EPA in writing within **60** days after EPA publishes the emission models applicable to the emission units at that source or facility.
- If the emission models demonstrate that a source triggers CAA permitting requirements, the source must submit all permit applications required by the permitting authority for the source within **120** days.
  - Agreement participants should consult the Agreement for additional specifics related to permitting requirements and control technologies.
  - Farms installing waste-to-energy systems will have an additional **180** days to submit permit applications.
- The annual emissions from a source shall be determined based on current operating methods and on the maximum number of animals housed at the source at any time over the **24** months prior to EPA's publication of the applicable emission models.

NAEMS Overview

- Two-year, industry-funded study resulting from the Agreement.
- Monitored 25 sites (e.g., barns and lagoons) for H_2S, NH_3, PM and VOCs.
- Species: Swine, dairy, egg-layers and broilers; beef cattle and turkey are not included in this study.
- Sites selected based on representation of animal species and geographic location.



NAEMS Timeline

- **2007 – 2010:** NAEMS monitored farm emissions
- **2013:** First group of draft emission models reviewed by EPA's Science Advisory Board (SAB)
- **2014 – 2016:** Gathered data and conducted analyses per SAB recommendations
- **2017 – 2020**: Issued QAPP for data analysis and revised methodology to develop emission models
- **2020 – 2022:** Issue draft models on a rolling basis, by animal species

Model Development Overview

- Select parameters
  - Considered data quantity and potential ease of measurement for a producer
- Create test models for daily emissions
- Select daily emission model
- Evaluate model
- Develop annual emission estimates and estimates of uncertainty

Models Development: Phases of Swine Production

- Based on literature and data analysis, the different phases of swine production and manure management systems can contribute to differences in emission rates.
- EPA developed separate models for:
  - farrowing rooms
  - gestation barns with shallow pits
  - gestation barns with deep pits
  - grow-finish barns with shallow pits
  - grow-finish barns with deep pits
  - lagoons for breeding-gestation farms
  - lagoons for grow-finish farms
  - basins

Models Development: Daily Model Form

$$Y_p(\ln\{pollutant\}) = \beta_0 + \beta_1 \mathrm{X}_1 + \beta_2 \mathrm{X}_2 + \ldots + \beta_k \mathrm{X}_k$$

Where:

Y_p is the log transformed emissions

β_0 is a constant

X_i is a predictive parameter (e.g., ambient temperature, wind speed)

β_i is the coefficient for parameter X_i

Model Development: Annual Emissions Estimate

- Estimate annual emissions by summing the daily emissions over the course of a year
- Develop uncertainty estimates for each annual model
- Develop total farm uncertainty by combining the uncertainty for each component of the farm (e.g., barns and lagoons)

Improvements from Previous Emission Models

- Used linear regressions, which prevents inconsistent results for extreme values
- Adjusted parameter selection to include more robust literature review
- Expanded the criteria to evaluate model performance
  - Added residual plots (i.e., model fit plots) and calculated model performance statistics.
- Refined evaluation approach to the “minus-one-house” technique, which is a more refined statistical approach with temporally correlated data

Uses of the Emission Models

- These models *estimate* emissions.
- Air Compliance Agreement participants ***must*** use the final models to determine whether their emissions trigger certain Clean Air Act permitting requirements.
- Other swine AFOs ***may*** use the final models to determine whether their emissions trigger certain Clean Air Act permitting requirements.
- The final models may also be useful for general estimates of emissions from swine operations across the US or comparisons between operations in different regions.
- The current *draft* models should ***not*** be used for these purposes until they are finalized.
- When the models are final, EPA will provide a tool that will apply the models to estimate emissions for farms.

Limitations of the Emission Models

- The models do not estimate emissions from all pollutants, or all emission sources found on swine operations.
- The models do not incorporate all the site-specific management factors that can affect emissions.
- The models cannot be used to quantify impacts of best management practices on emissions.

Schedule

Date	Milestone	Status
September 2019	Call for Information for additional VOC data	Complete
August 2020	Draft models for ammonia, hydrogen sulfide and particulate matter emissions from swine farms	Complete
June 2021	Draft models for ammonia, hydrogen sulfide and particulate matter emissions from poultry (broiler and layer) farms	In Progress
December 2021	Draft models for ammonia, hydrogen sulfide and particulate matter emissions from dairy farms	
February 2022	Draft models for volatile organic compound emissions from swine, poultry and dairy farms	
TBD	Stakeholder review period	
TBD	Finalization of all AFO emission models	

- Schedule is available on the project website: www.epa.gov/afos-air/national-air-emissions-monitoring-study#naems-status

Contact Information

www.epa.gov/afos-air/national-air-emissions-monitoring-study

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This report is an external draft for review purposes only and does not constitute U.S. Environmental Protection Agency policy.

Appendix: Swine Emission Models

Emission Models: Farrowing Rooms

Manure Management System	Pollutant	Intercept	Cycle day	Ambient Temperature (°C)	Live Animal Weight (thousands of kg)	Ambient Relative Humidity (%)
All	H_2S	2.142329	0.129797		0.061406	
All	NH_3	0.68875	0.001961	0.000581	0.008405	
All	PM_{10}	2.489915	0.055625		0.106263	***-0.003436***
All	$PM_{2.5}$	***-1.21456***	0.075902		0.256357	
All	TSP	2.858928	0.070551		0.147305	***-0.004908***

Emission Models: Breeding and Gestation Barns

Manure Management System	Pollutant	Intercept	Ambient Temperature (°C)	Live Animal Weight (thousands of kg)	Ambient Relative Humidity (%)
Not Specified/No Pit	H_2S	2.077258	0.003547	0.019862	
	NH_3	0.154785	0.006855	0.009122	
Deep	H_2S	3.171852	0.003844	0.019592	
	NH_3	0.834777	0.011778	0.007899	
Shallow	H_2S	2.130472	0.003844	0.019592	
	NH_3	0.30747	0.011778	0.007899	
All	PM_{10}	5.186761		0.005472	***-0.007661***
	$PM_{2.5}$	4.88715		0.0007	
	TSP	5.533966		0.006601	***-0.008***

Emission Models: Grow-Finish Barns

Manure Management System	Pollutant	Intercept	Ambient Temperature (°C)	Live Animal Weight (thousands of kg)	Ambient Relative Humidity (%)
Not Specified (No Pit)	H_2S	4.081979	***-0.006592***	0.017163	
	NH_3	1.236262	0.008953	0.008939	
Deep	H_2S	4.991579	***-0.005539***	0.013317	
	NH_3	1.342386	0.009077	0.008545	
Shallow	H_2S	4.190492	***-0.005539***	0.013317	
	NH_3	1.142239	0.009077	0.008545	
All	PM_{10}	5.503943		0.010447	***-0.009403***
	$PM_{2.5}$	2.49543		0.01095	***-0.002279***
	TSP	6.26614		0.011813	***-0.008831***

Emission Models: Lagoons and Basins

Source	Operation Type	Pollutant	Intercept	Ambient Temperature (°C)	Wind Speed (ms^{-1})
Lagoon	Breeding - Gestation	H_2S	4.435746		0.236141
Lagoon	Breeding - Gestation	NH_3	0.582053	0.055673	0.091428
Lagoon	Grow-Finish	H_2S	3.694758		0.279011
Lagoon	Grow-Finish	NH_3	-0.680078	0.085372	0.131932
Basin	Grow-Finish	H_2S	0.4689	0.027	
Basin	Grow-Finish	NH_3	1.5049	0.01171	