NH_3 Emissions from Poultry Layer Operations

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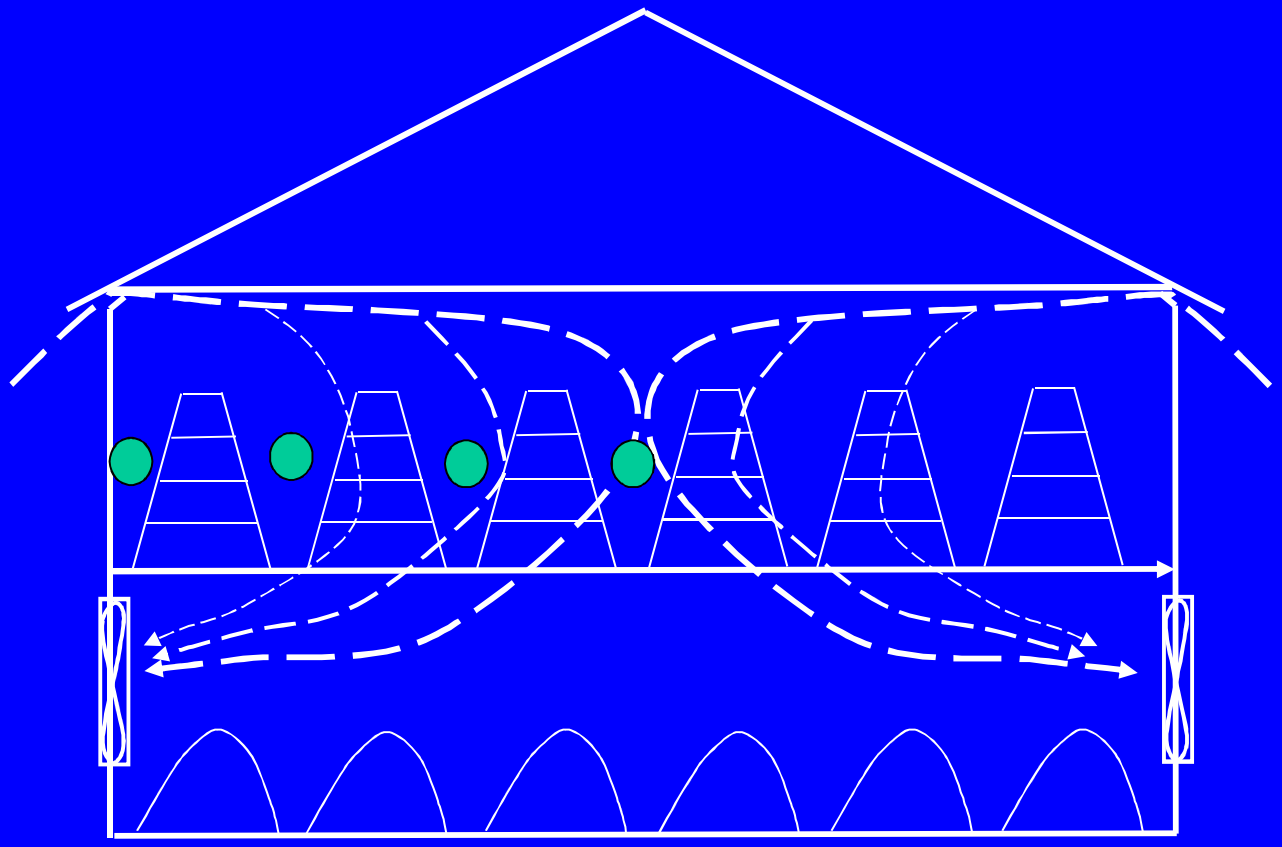
Overview

- Layer facilities and air emissions
- Studies and Measurement methods on ammonia emissions
- Ammonia concentrations and emissions of layer facilities
- Conclusions

High-rise deep-pit (HR) layer barn

- 69% of existing layer facilities in the U.S.

Schematic of High-rise Deep-pit Layer Facility



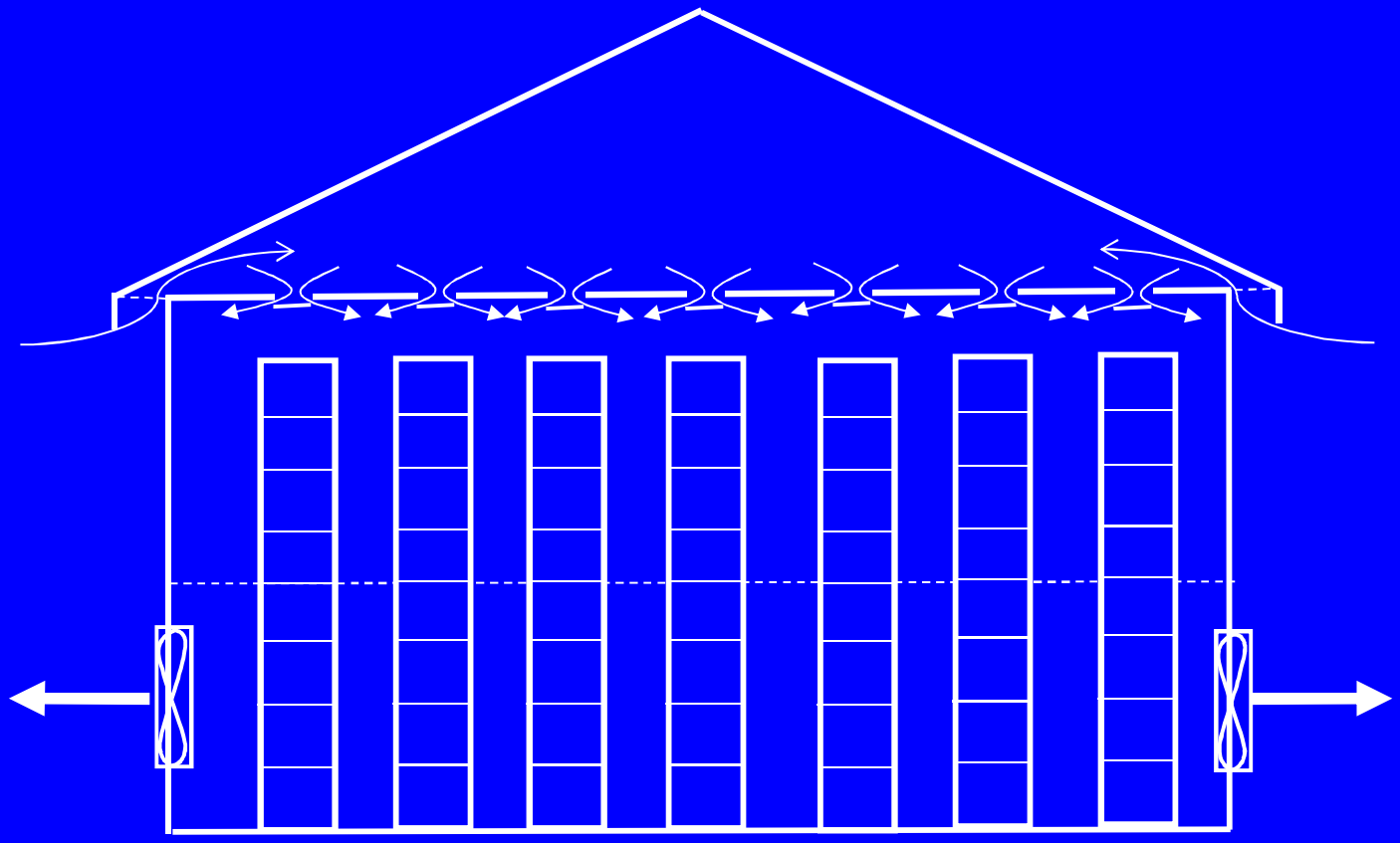
56’x590’ laying house with deep pit

Manure-belt (MB) layer barns

- 24% of existing layer facilities in the U.S.

- 70% new layer facilities in the U.S.

Schematic of Manure-Belt Layer Facility



Air emissions from Layer Facilities

The major air emissions associated with layer facilities:

- Ammonia
- Airborne particles (particulate matter)
- Odor and Volatile Organic Compounds (VOCs)
- Microbial organisms

Measurement and Control of Ammonia and Particulate Air Emissions from Laying Barns

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Lingying Zhao, Associate Professor, OSU
Dr. Teng Lim, Research Associate, Purdue University
Dr. Ji-Qin Ni, Technical Director, Purdue University
Dr. Huwei Sun, Research Associate, OSU
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Objectives

1. Quantify and characterize baseline particulate (PM) and NH_3 emissions rates for two types of laying facilities.

2. Demonstrate efficiency of a series PM and NH_3 abatement technologies, including PM impaction system, new diet, enzyme-based manure additives, alum, and an electrostatic space charging system.

Characterization and Abatement of NH_3, PM, Pathogen and Odor Emissions from Manure-Belt Layer Barns and Composting Facilities

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Sponsor: USDA NRI air quality program
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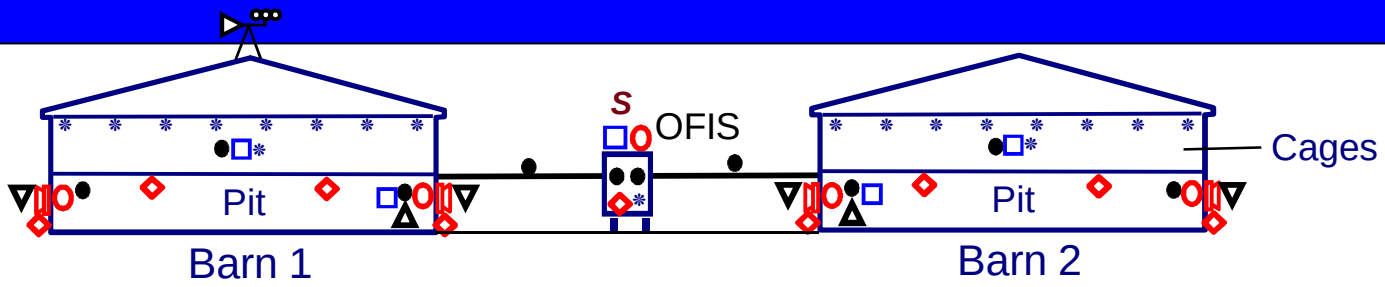
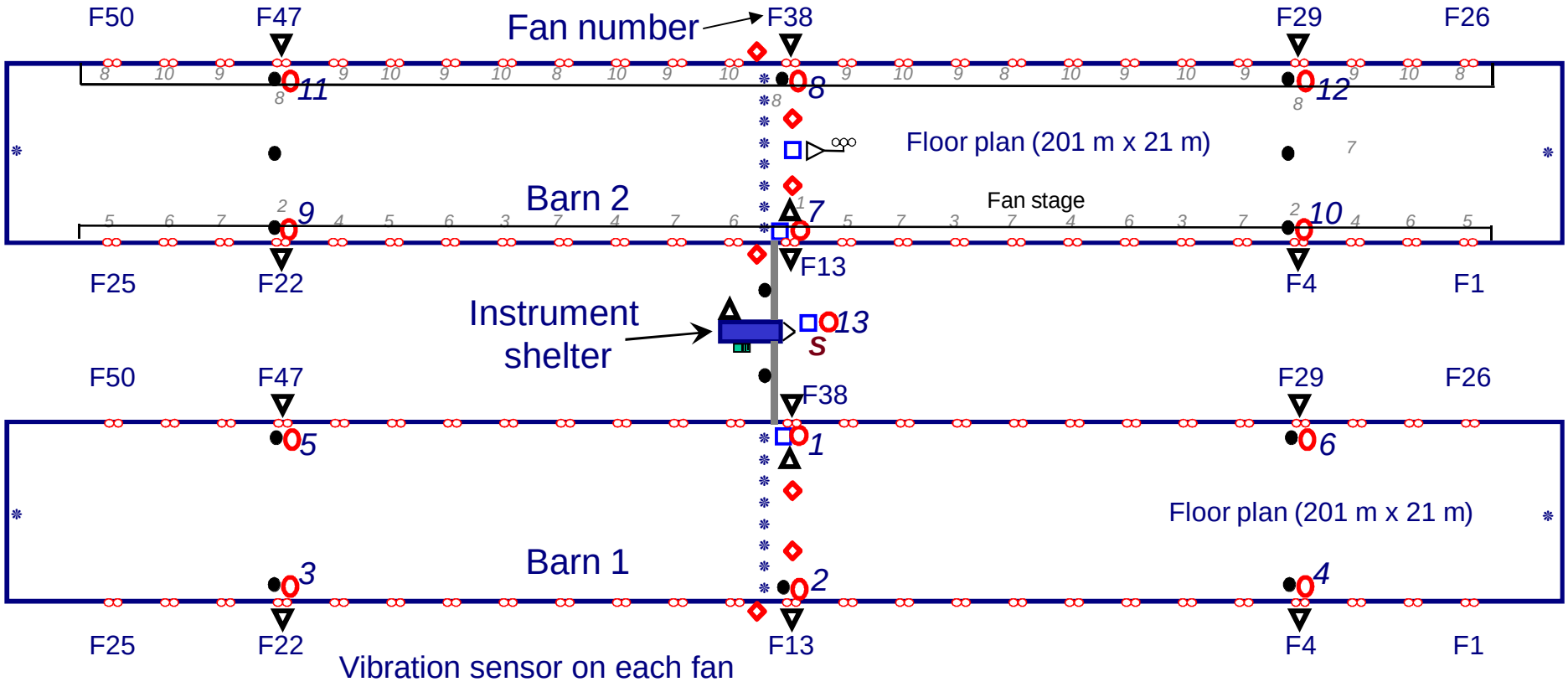
Objectives

1. Determine baseline air emissions (NH_3, PM_{10}, $PM_{2.5}$, odor, and pathogen) from egg production facilities,
2. Test the hypothesis that belt battery barns emit less air emissions than conventional deep pit barns with replicated field tests.
3. Quantify effects of litter composting on air emissions from egg production facilities.

Monitoring Plan for Mt. Victory, Ohio



Thermocouple
Air sampling (1-13)
Anemometer (SVA)
RH/Temp probe
Static pressure port
TEOM PM monitor
Activity sensor
Wind sensor
Solar sensor



Mobil Air Emission Lab

Gas Analyzers

NH_3-1-TEI 17C Chemiluminescence Ammonia Analyzer

- **Chemiluminesence** uses indirect measurement of ammonia by conversion to NO, and mathematical or chemical subtraction from the total nitrogen content;

  Has 1 ppb detection limit

http://www.thermo.com/eThermo/CMA/PDFs/Product/productPDF_12263.pdf

15

NH_3-2-MSA Chilgard RT Ammonia Analyzer

http://media.msanet.com

- Photoaccoustics uses gas irradiated with intermitent light of specific wavelength and converts it to acoustic signal,
- Has 2 ppm detection limit.

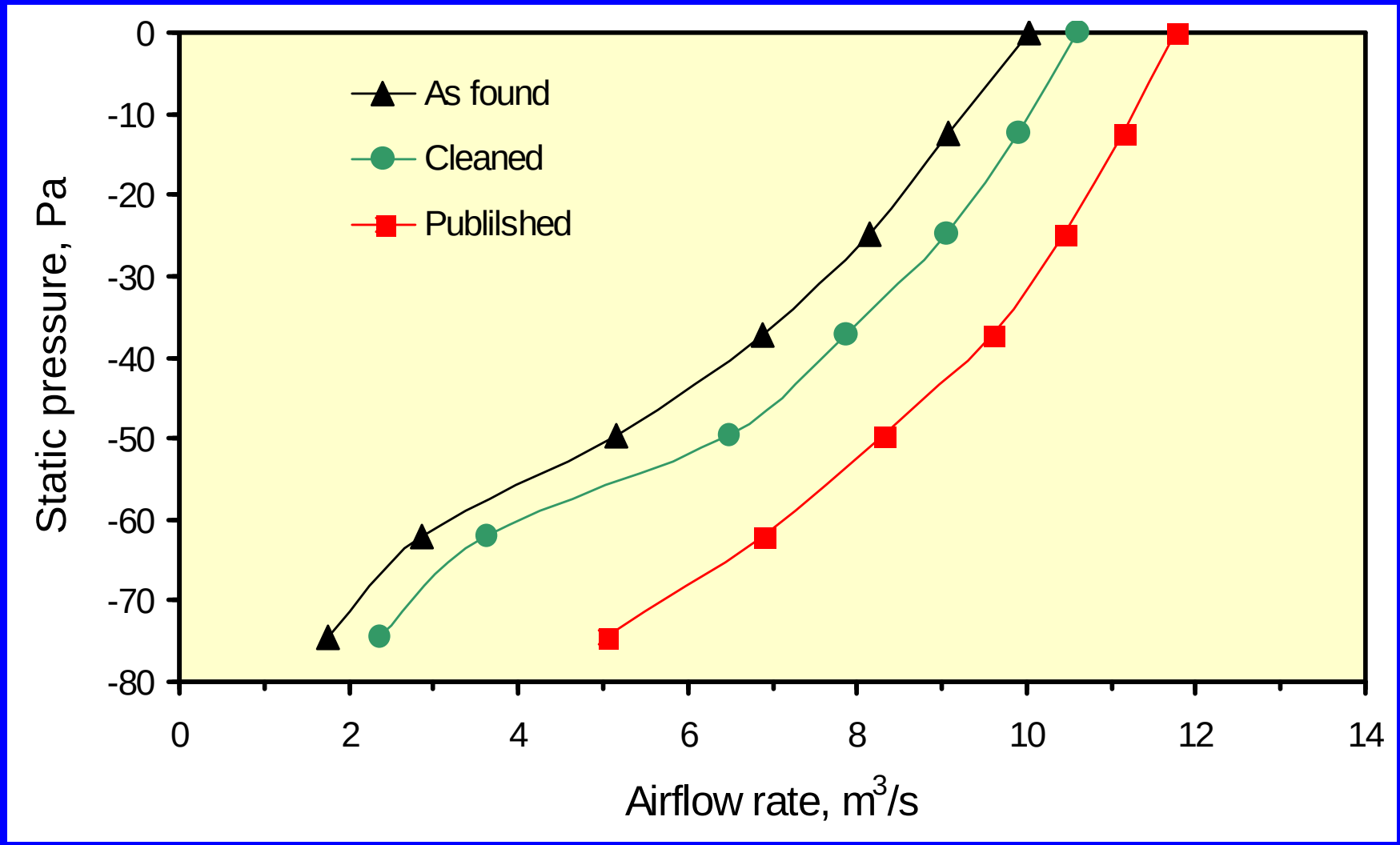
16

Air Flow Measurements

- Fan activity was measured using vibration sensors (left),
- Fan airflow was indirectly estimated by means of manufacturer fan curve and building pressure measurements, and
- Fan curves were calibrated using Flow Assessment Numerations System (FANS) (right).

Flow S)

Fan Performance Curves



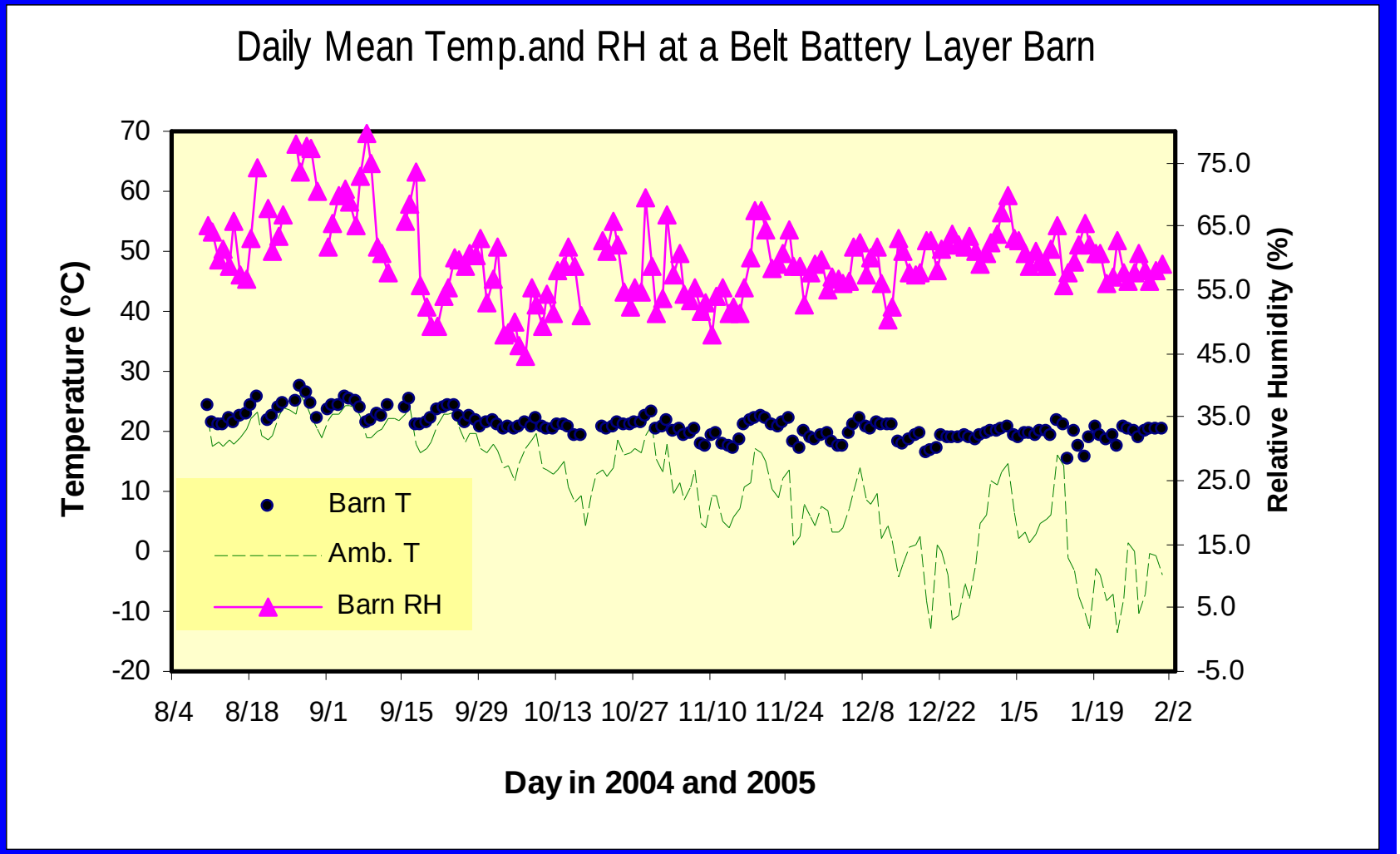
NH_3 Emission Calculations

$$E = Q_{actual} * \frac{M}{0.0821*(273+T_{exhaust})} * (C_{out} - C_{in})$$

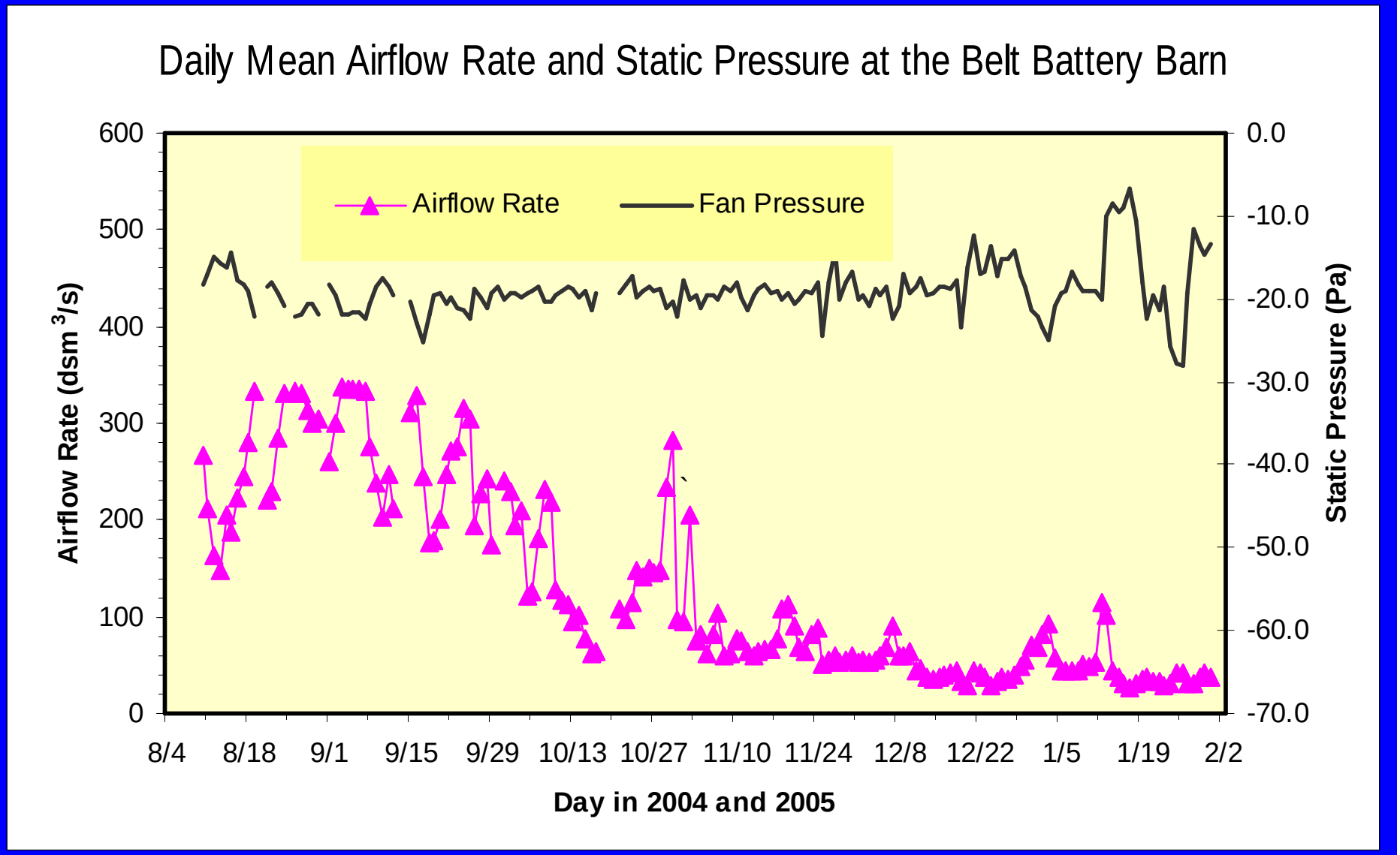
Where:

E	ammonia emission rate from barn, mg/s
Q_{actual}	outlet airflow rate at $T_{exhaust}$, m^3/s
C_{out}	outlet gas concentration, ppm
C_{in}	inlet gas concentration, ppm
M	ammonia molecular weight
$T_{exhaust}$	temperature at the outlet sampling location

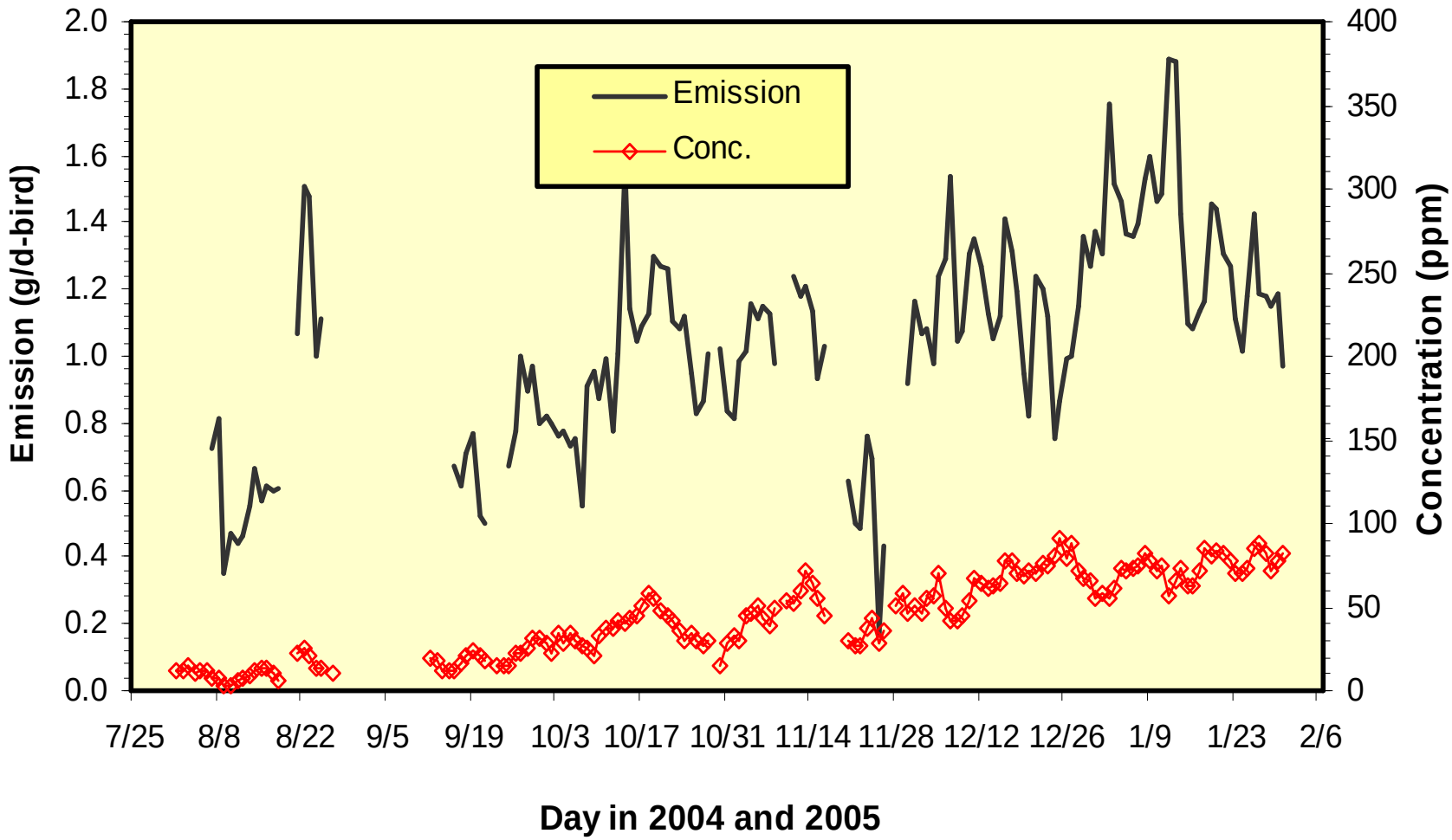
Indoor Environment



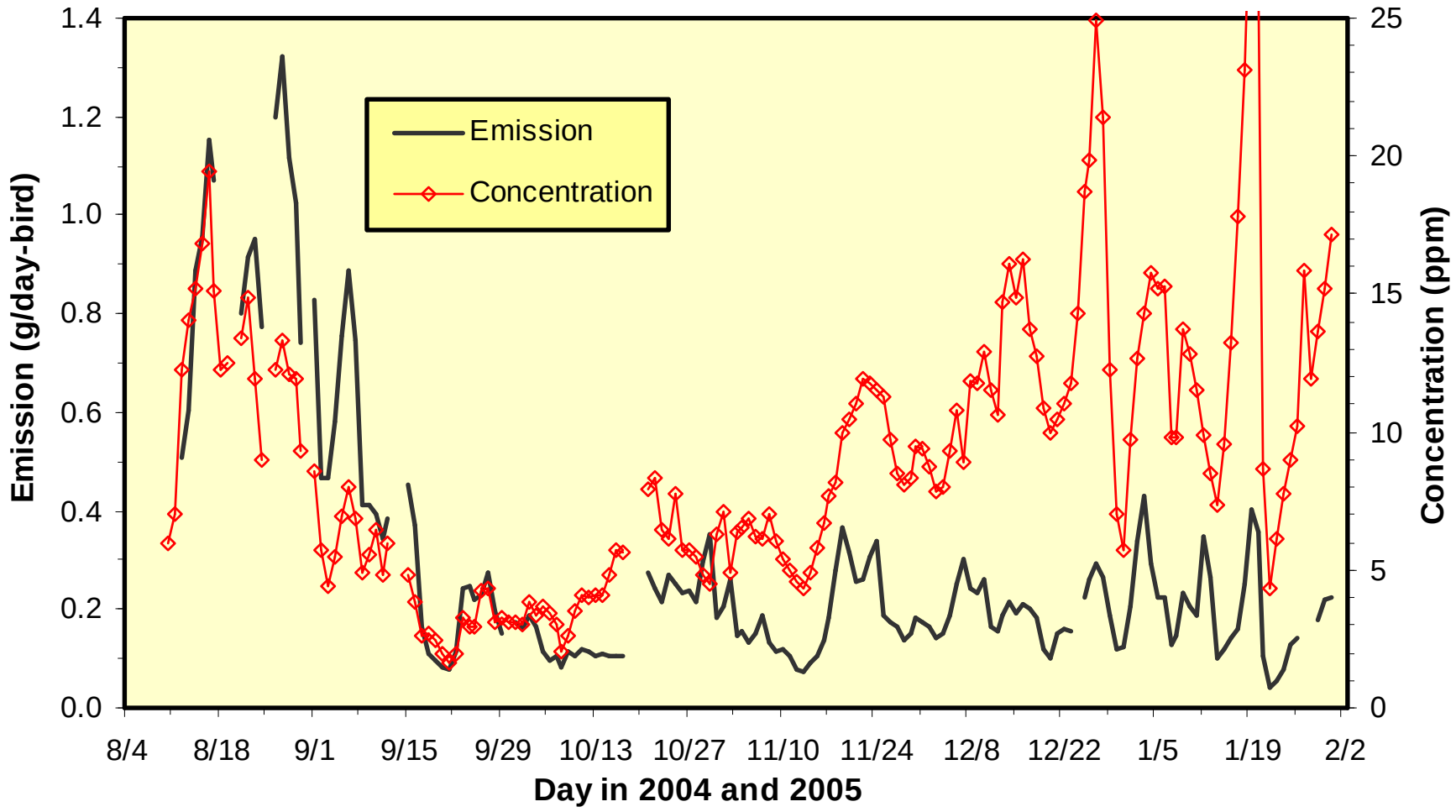
Ventilation Rates



High-Rise Barn- NH_3 Concentration & Emission



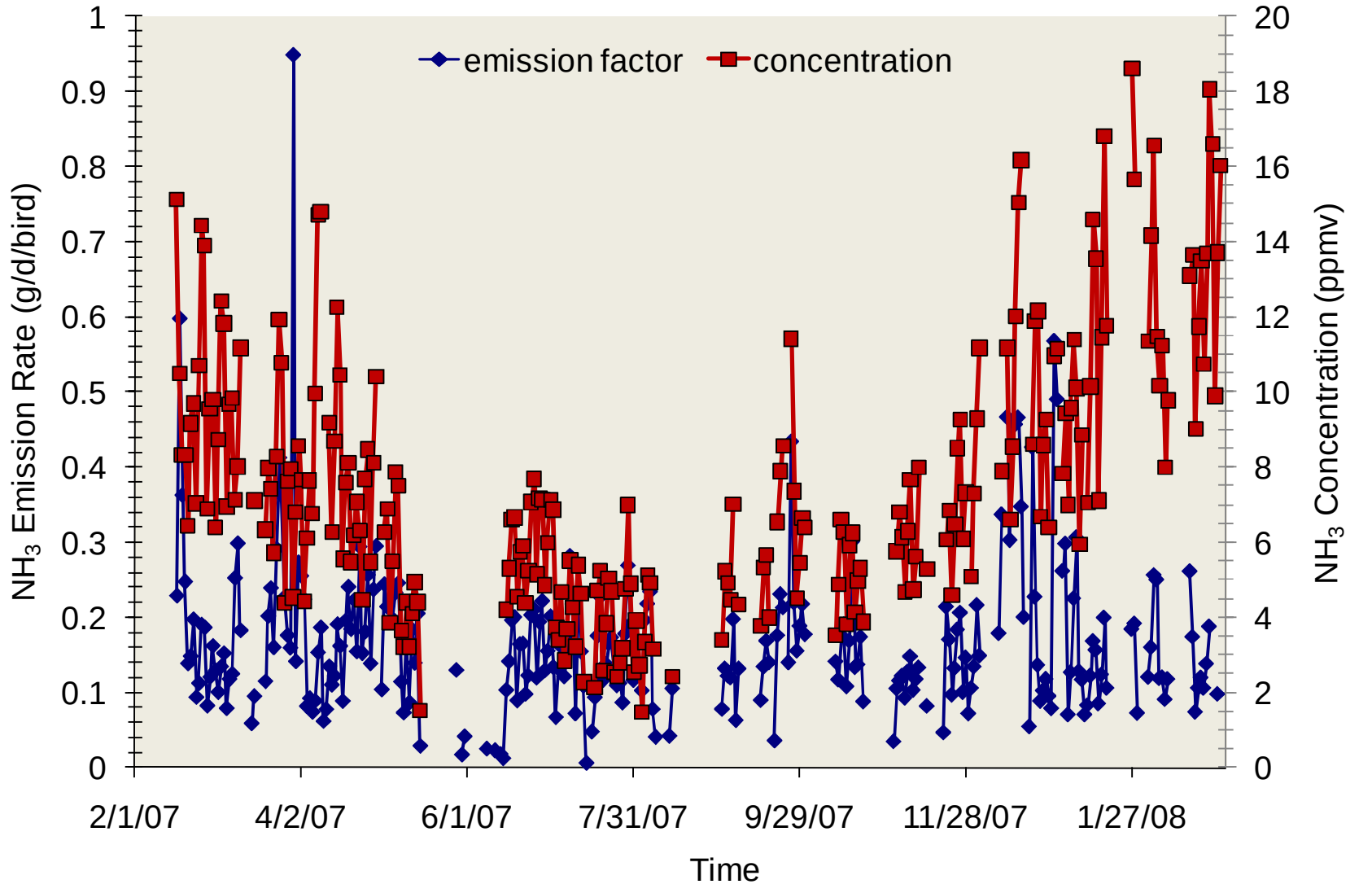
Manure-Belt Barn—
NH_3 Concentration & Emission



Summary of Results

	Manure-Belt Barn	High-Rise Barn
NH_3 Concentration (ppm)	9.1	40
NH_3 Emission (g/d-bird)	0.29	1.03

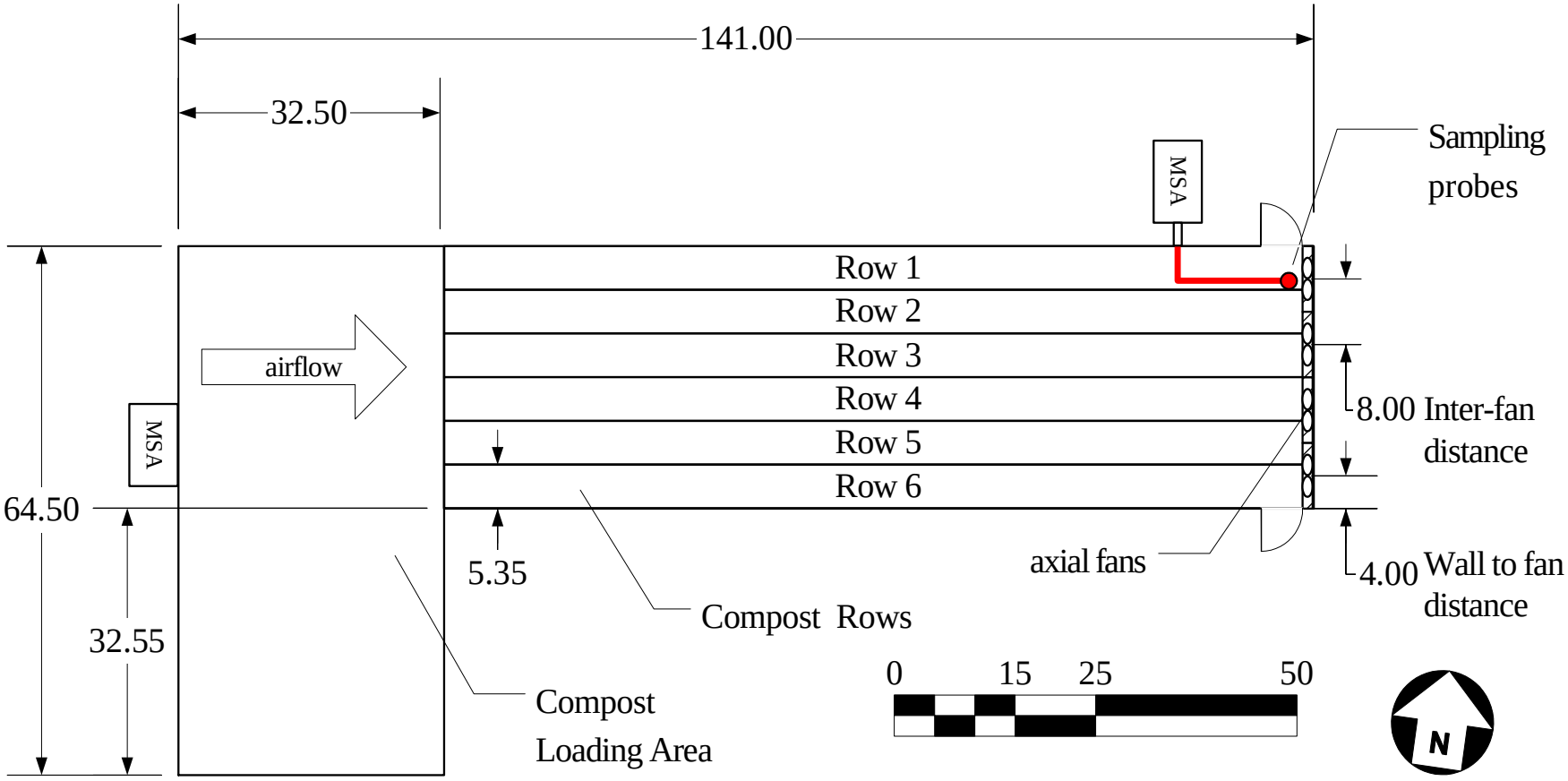
Ammonia Concentrations & Emissions from Manure-Belt Layer Facilities



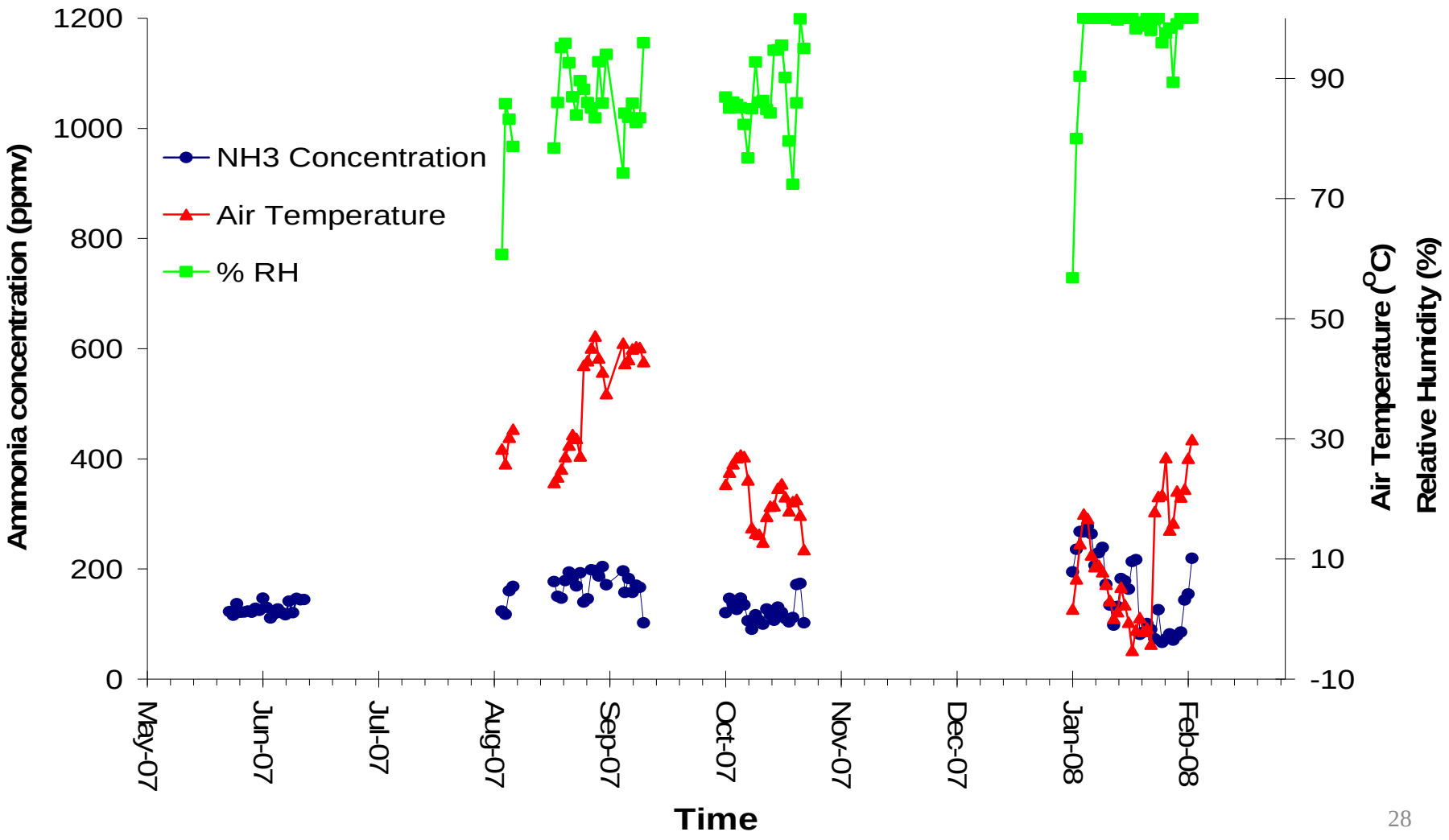
Ammonia Concentration and Emission Annual Summaries

	Daily Average NH_3 Concentration (ppmv)			Daily Average NH_3 Emissions (g/d/bird)		
	ave ± sd	max	min	ave ± sd	max	min
Barn 1	6.6 ± 4.7	18.6	0.1	0.14 ± 0.09	0.45	0.00
Barn 2	6.9 ± 4.9	25.8	0.1	0.18 ± 0.16	1.8	0.01
Total	6.7 ± 4.3	25.8	0.1	0.16 ± 0.13	1.8	0.00

NH_3 Emission from a Layer Manure Composting Facility



Seasonal Variations in Ammonia Concentrations and Emissions



Emission Rates and Factors

	Spring	Summer	Fall	Winter	Annual Average
NH_3 emission rates ($Kg\ d^{-1}$) (Ave.± Std.)	231 ± 20	315 ± 49	243 ± 41	263 ± 109	263 ± 37
NH_3 emission factors ($Kg\ ton^{-1}\ d^{-1}$) (Ave.± Std.)	10.5 ± 1.3	26.4 ±2	12.3±0.9	12.5 ± 1.1	15.4 ± 1.3
NH_3 emission factors ($g\ d^{-1}\ hen^{-1}$)	0.23	0.53	0.25	0.26	0.32± 0.14
Annual emission rate ($Kg\ yr^{-1}$)	96143				

Conclusions of Study 1

- The average daily mean ammonia concentrations from ammonia the MB layer facility was 9.1 ppmv ranging from 2 to 25 ppmv.
- The average daily mean ammonia concentrations from ammonia the MB layer facility was 40 ppmv ranging from 0 to 90 ppmv.
- NH_3 emission rate: 0.29 g/day-hen for the BB barn and 1.03 g/day-hen for the HR barn.
- 44,400 hens from the HR barn or 158,000 hens from the BB barn would emit 100 lb NH_3/day.

Conclusions of Study 2

- The average daily mean ammonia concentrations from ammonia the MB layer facility was 6.7 ± 4.3 ppmv ranging from 0.1 to 18.6 ppmv;
- The average daily mean ammonia emissions from the MB layer facilities was 0.16 ± 0.13 g/d/bird ranging from 0.007 to 1.78 g/d/bird.
- The daily average NH_3 concentrations in the MB layer manure composting facility varied from 123 to 278 ppm in a year.
- The daily average NH_3 emission rates varied from 114 to 426 kg d^{-1}.
- The annual NH_3 emission rate was estimated as 96,143 kg. The emission factors were calculated as 0.32 ±0.14 g d^{-1} hen^{-1}.

Thanks.

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