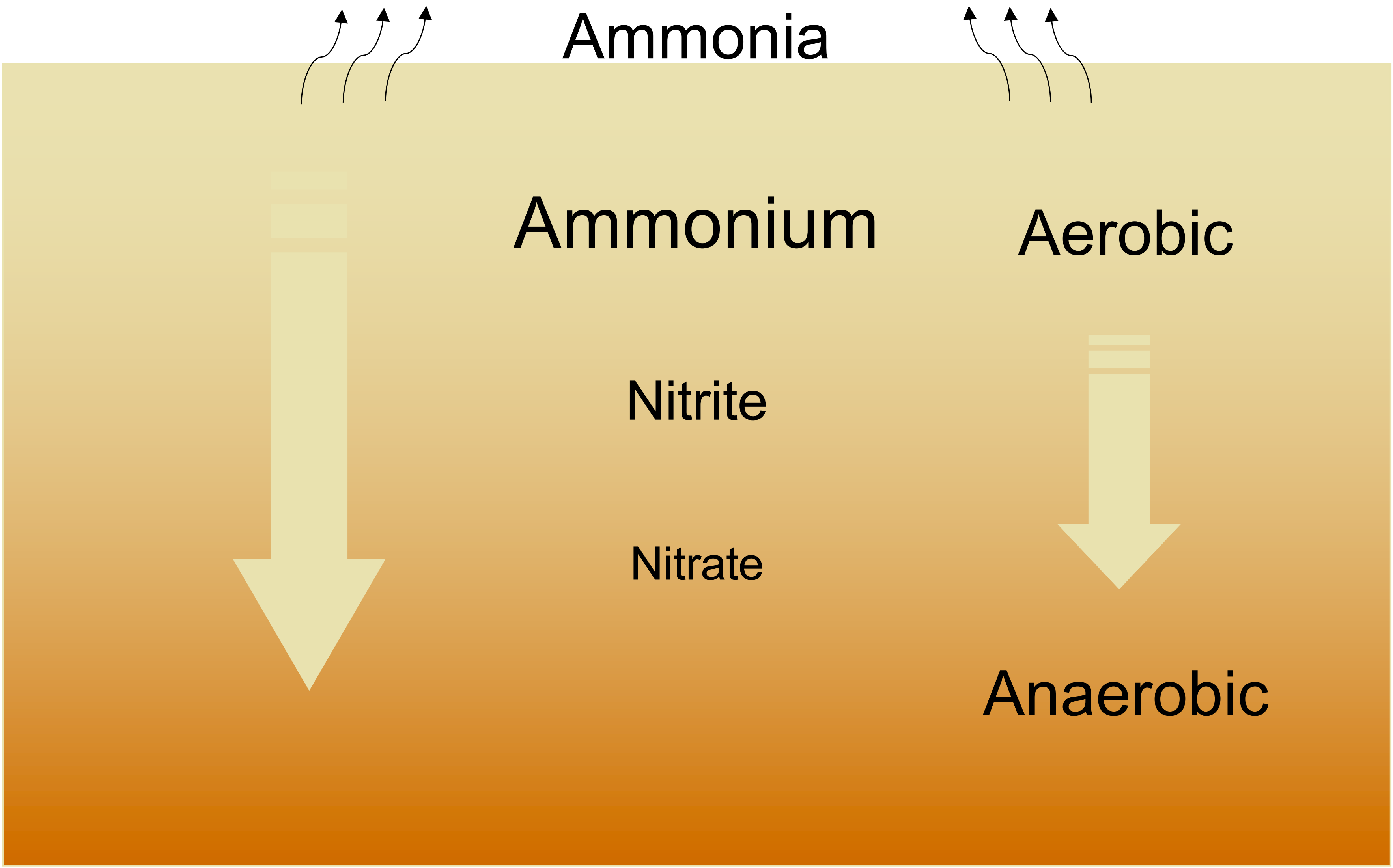
Ammonia Emissions

STAC Workshop: The Role of Litter Amendment Use in the Delmarva Broiler Industry

Casey Ritz, Ph.D.
University of Georgia

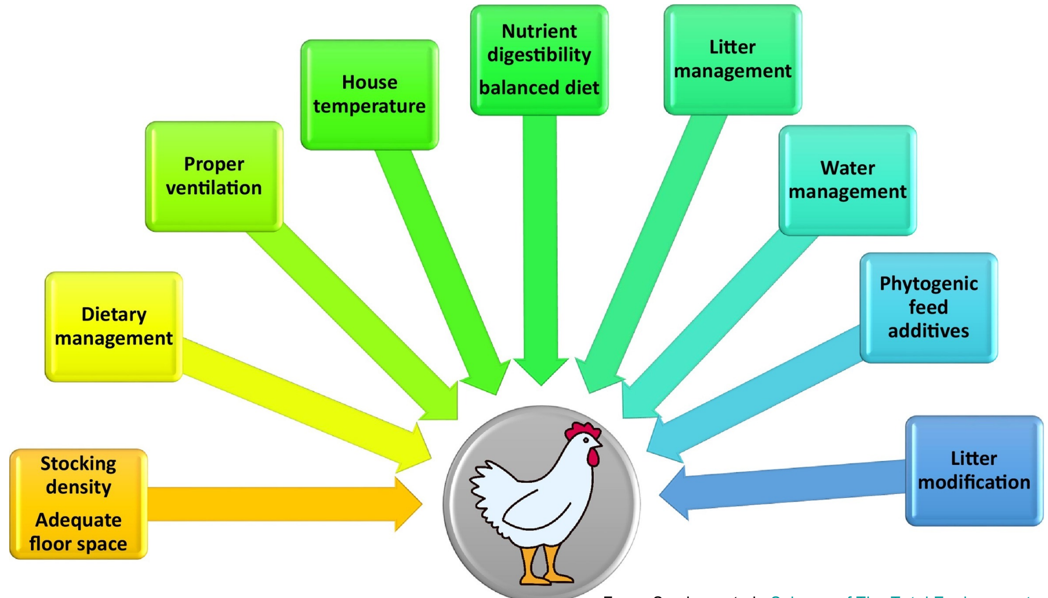
May 4, 2022

Built-up Poultry Litter Profile



In-house Emission Impact Factors

- Age of litter
- Litter moisture
- Temperature
- Relative humidity
- Bird density
- Market age
- Diet manipulation
- Health status
- Amendments
- Litter management and movement



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Implications of Ammonia Production and Emissions from Commercial Poultry Facilities: A Review

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Primary Audience: Poultry Farm Managers, Integrators, Researchers, Regulatory Agencies

SUMMARY

For the poultry industry, concerns about ammonia are multifaceted and include issues of live production performance, animal health, and welfare, and environmental impact. Retail industry marketers, as a component of their evolving animal care audit programs, are issuing guidelines for the control and reduction of ammonia within poultry facilities to address animal welfare concerns. At the same time, pressure is being placed on poultry producers from interested groups and neighbors to reduce ammonia emissions for environmental reasons. Since the current procedure for reducing ammonia levels in houses is to exhaust air as much as possible, this will, in some part, conflict with efforts to reduce ammonia emissions from poultry live production facilities. Research will be needed from the industry and academia to develop methods of reducing nitrogen excreted by poultry, e.g., research in nutrition, genetics, poultry husbandry, and management. Research is needed to improve or develop methods of manure management and treatment that will reduce ammonia emissions. Research is also needed in developing methods of closing the loop, using nitrogen in poultry manures to produce crops that can be fed back to poultry. Importing major quantities of feedstuffs from other regions of the country and depositing manure onto low-productivity pastures or cropland may not be sustainable. Some combination of reducing excess nutrients in manure, alternative uses for these nutrients, shipping excess nutrients back to grain producing areas, or increasing grain production in poultry-producing areas will be required to address environmental concerns and minimize regulatory advances.

Key words: poultry, ammonia, emission, health

2004 J. Appl. Poult. Res. 13:684–692

NITROGEN IN POULTRY PRODUCTION

Nitrogen, in appropriate form, is an essential element for all plants and animals. Each year in the US, it is estimated that 18.5 million metric tons of N is added to cropland mainly through inorganic commercial fertilizer [1]. Whatever N is not removed by the crop can potentially be lost into the environment, depending on site-specific environmental factors.

Considerable quantities of N are consumed in feed and excreted by poultry. The excretion of N is largely due to the excess protein and amino acids fed to poultry. This excess occurs because the ratios of amino acids in the feedstuffs fed to poultry are not perfectly balanced

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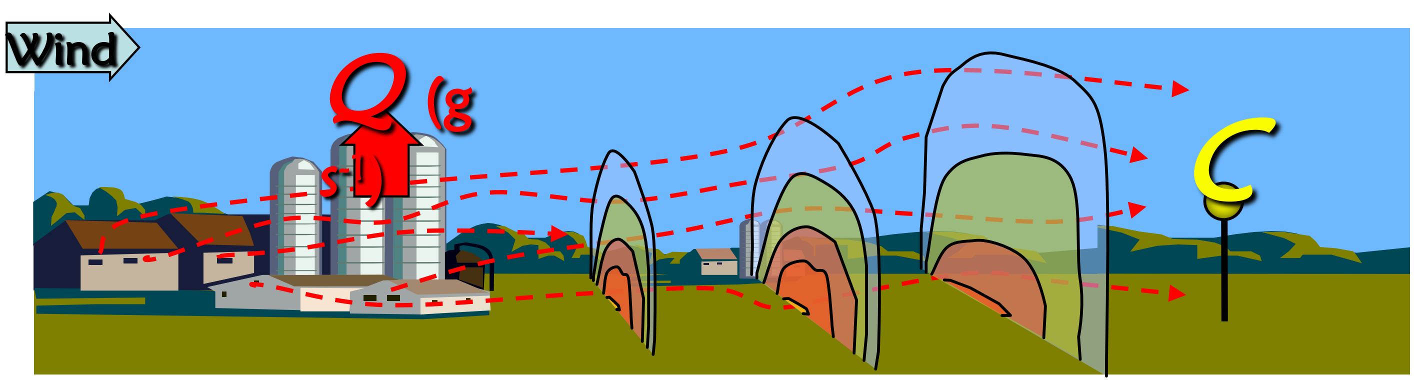
External Emission Impact Factors

- Seasonality
- Geographical location, topography / terrain
- Ambient temperature – vertical heat flux
- Relative humidity
- Weather patterns
- Atmospheric stability - wind direction & intensity

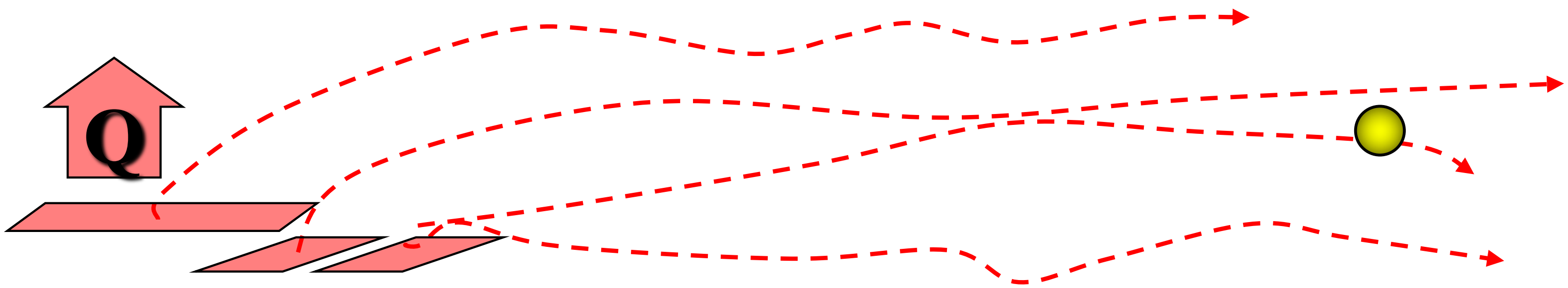


How do we obtain downwind concentrations?

- **Measurement**
  - Gas washing, electrochemical sensors, photoacoustic spectroscopy, chemiluminescence, etc.
    - Disadvantages or potential problems – NH_3 absorption/desorption by equipment, drift/interference, expense, point source bias, representativeness of the measured concentration, etc.

How do we obtain downwind concentrations?

- **Measurement**
- **Dispersion analysis modeling**
  - Gaussian
  - Lagrangian – more appropriate for agricultural site situations.
    Height < 10 m, horizontal distance < 1000 m, based on stochastic dispersion and climate parameters, good accuracy (± 20%)



Ammonia concentrations downstream of broiler operations[1]

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Primary Audience: Poultry Producers, Government Environmental Agencies, Researchers

SUMMARY

Within broiler production facilities, NH_3 concentrations have always been of concern from a bird performance and worker health standpoint. However, NH_3 emitted from poultry houses is receiving increased attention from the environmental and community nuisance perspectives. Studies on NH_3 emissions from poultry operations found within the literature do not address how NH_3 disperses or the actual concentrations observed at varying distances downwind from poultry houses. The objective of this study was to measure downwind NH_3 concentrations emitted from broiler houses when ventilation rates would be at a maximum. Open-path laser spectrometers were utilized for this study and for period 1 were placed 100, 200, and 300 ft from the houses from 28 to 49 d and in period 2 were placed at 100, 200, and 500 ft from 50 to 56 d. Data were collected during the last 4 wk of a 56-d grow-out cycle in 2 periods during a summer flock on a 4-house broiler farm located in northeastern Georgia. Ammonia concentrations were lower as distance from the houses increased, with NH_3 levels at 100, 200, 300, and 500 ft being less than 1 ppm in approximately 60, 75, 85, and 90% of the observations, respectively. Ammonia concentrations extending to 100 ft from the houses were influenced by the tunnel fans themselves. Wind direction and wind speed were the factors that significantly influenced downstream NH_3 concentrations beyond 100 ft. At no time did measured NH_3 levels meet or exceed established Occupational Safety and Health Administration-US Environmental Protection Agency NH_3 odor-detection threshold values during this study.

Key words: wind speed, climate, wind direction, emissions

2009 J. Appl. Poult. Res. 18:630–639
doi:10.3382/japr.2008-00126

DESCRIPTION OF PROBLEM

Air emissions are important issues for the poultry industry from both environmental and nuisance viewpoints. The 2004 report from the National Academy of Sciences Ad Hoc Committee on Air Emissions from Animal Feeding Operations concluded that the existing data in the literature regarding NH_3 emission rates from animal feeding operations was inconsistent and

[1]Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by The University of Georgia.
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LIVE PRODUCTION

Measuring ammonia odors from poultry houses

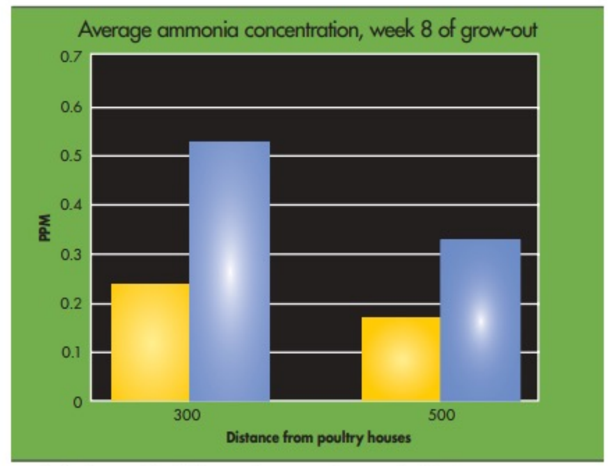
Ammonia is typically the focus of nuisance litigation associated with odor from poultry facilities, but should it be?

BY CASEY RITZ, BRIAN FAIRCHILD, MICHAEL CZARICK AND JOHN WORLEY

Odors and air emissions are natural occurrences from nearly every agricultural enterprise. This is true for animal production facilities, including poultry farms. Most people in rural communities are familiar with the odors and noises associated with rural living. However, as more people who are disconnected from agriculture and how their food is produced move into the rural landscape, tolerance of the aromas emanating from animal production facilities is waning.

There are numerous gases and organic compounds that make up odors and emissions, with the most prominent odor compounds from animal manures being the volatile fatty acids by virtue of their high concentrations or their low odor thresholds. Hydrogen sulfide, for instance, is a primary compound associated with swine odor (commonly identified as "rotten egg smell").

Learn about 10 tips for reducing litter moisture (and ammonia) at www.WATTAgNet.com/8136.html



Day (yellow) versus night (blue) ammonia concentrations at week eight of grow-out.

Ammonia's role in litigation

Another manure-associated odor is ammonia. This colorless gas is often implicated or rather assumed to be the major component of poultry house air emissions in nuisance litigation associated with odor from poultry facilities. Ammonia is typically the focus due to its potential environmental and human health impact that can be associated with prolonged exposure at high levels.

Air emission studies have been conducted both nationally and internationally in an attempt to determine how much or what volume of ammonia is produced within poultry facilities. Obtaining an accurate measurement is complicated by the influence of numerous factors, such as temperature, moisture, air velocity, age of flock, season of year, bedding age and quality, house management practices, and so forth. The dispersion of ammonia or the concentrations of ammonia downwind from a poultry farm are another matter all together. Considering the possibility of litigation due to odor nuisance complaints, knowledge of ammonia dissipation is much needed information.

Testing a 'worst case' scenario

To that end, a group of poultry specialists and agricultural engineers

UGA Study

- Worst Case Scenario
  - Hot weather (summer)
  - Fans located across the entire end wall
  - Tunnel ventilation mode
  - Six or more fans running
  - Wind blowing in direction of sensors downwind of fans
  - Birds in last week of grow-out

Measurements:

Path average NH_3 concentrations -- 100 ft, 200 ft, 300 ft, and 500 ft downwind of the houses.

Meteorological information – windspeed, wind direction, humidity, ambient temperature, rainfall intensity and volume.

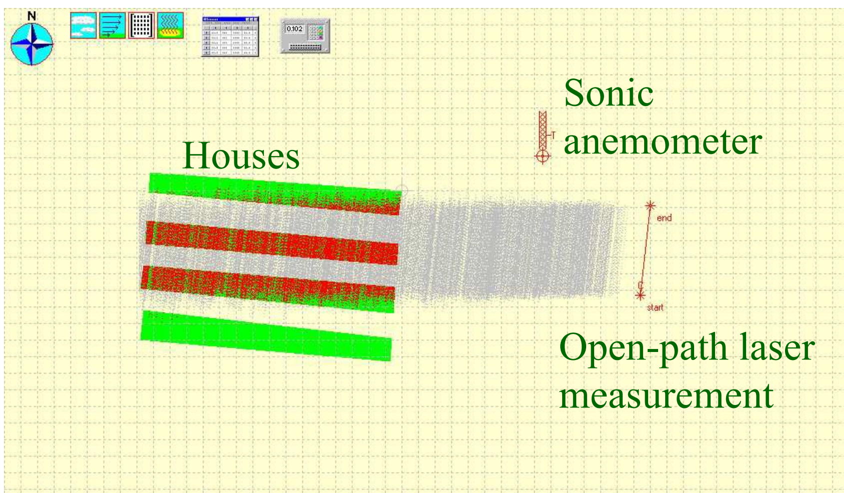
Climatological information – three dimensional vector wind velocity, turbulence parameters, thermal stability, and heat flux.

Management factors – Animal density, water use, fan run-time, house temperature and relative humidity.

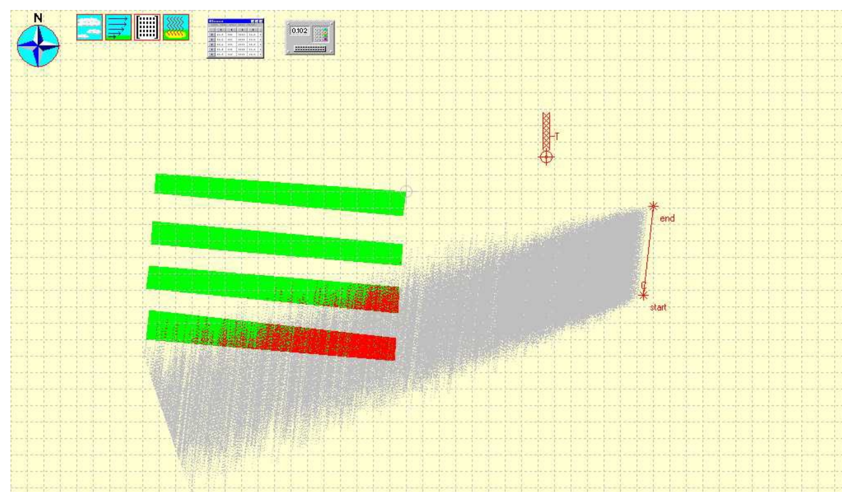
Data analysis:

Acceptable data – Upwind plume must cover at least 50% of the source area.

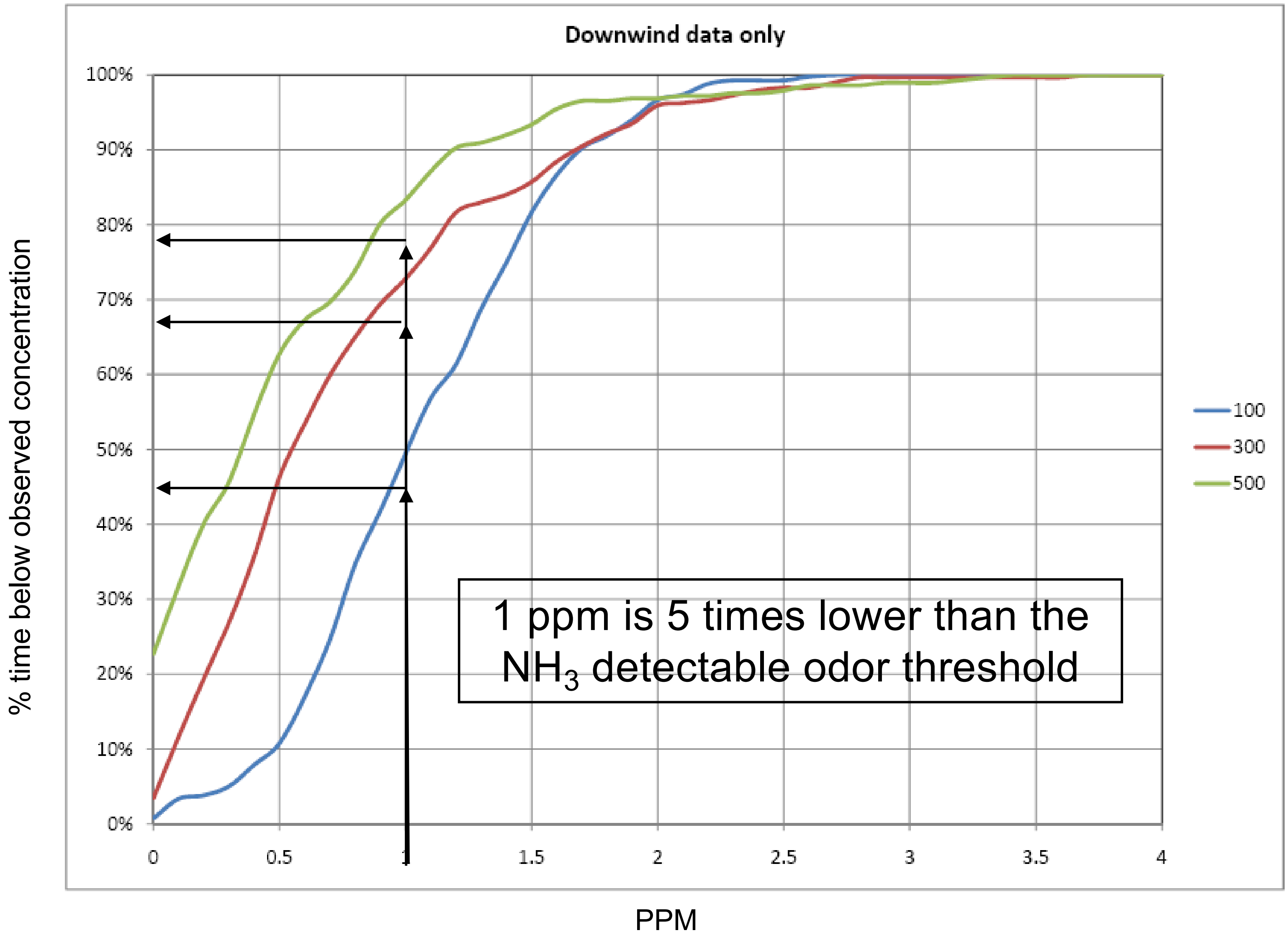
Acceptable data period



Unacceptable data period

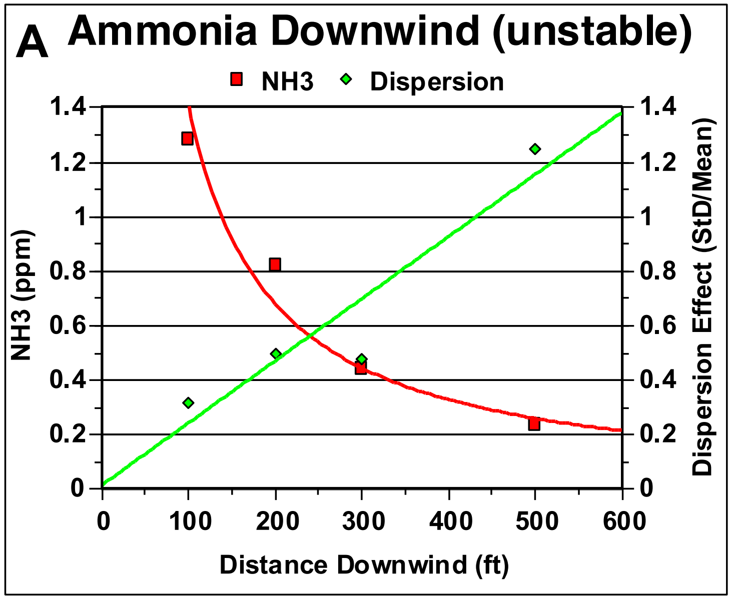


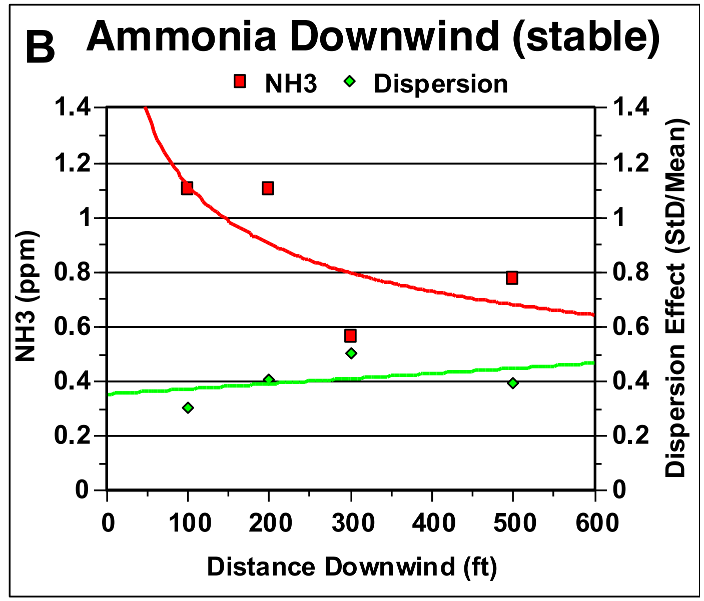
Observed NH_3 Concentrations



Measurement results:

Downwind NH_3 concentrations (broiler production).





Daily average NH_3 concentrations decrease rapidly during unstable (daytime) conditions as a power function with respect to downwind distance. The climatic dispersion effect* increases much more rapidly during unstable conditions.

Daily average NH_3 concentrations decrease minimally during stable (nighttime) conditions as a power function with respect to downwind distance. The climatic dispersion effect* has minimal effect during unstable conditions.

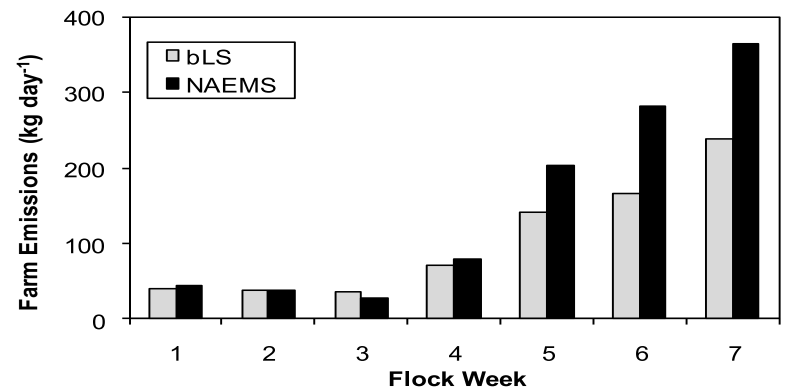
*The climatic dispersion effect is the variance of the daily NH_3 concentration divided by the daily mean concentration.

Ammonia Emissions from Broiler Production: Regional, Climate, and Measurement Technology Comparisons

L.A. Harper†, C.W. Ritz‡, and T.K. Flesch§

Questions:

1. **What is the cause for regional differences in ammonia emissions?**
2. **Why are simultaneous measurements different?**
3. **What is the most appropriate technique for evaluating trace-gas emissions?**
4. **Can downwind gas concentrations be predicted accurately?**
5. **What is the effect of climatic conditions on downwind gas concentrations?**



Comparison of annual NH_3 emissions between geographical areas and litter types.

Study	Location	Litter Conditions	Ammonia Emissions (kg NH_3 bird^{-1} year^{-1})
Germany	Europe	New litter[1]	0.016
United Kingdom	Europe	New litter[1]	0.040
California	Western U.S.	New litter[2,3]	0.099
Pennsylvania	Eastern U.S.	Built-up[1,4] (two to four flocks)	0.150
Texas	Southern U.S.	Built-up[1,4] (new litter to one flock)	0.180
Kentucky	Middle U.S.	Built-up[1,4] (two flocks)	0.230
Arkansas	Southern U.S.	Built-up[1,4] (one to two flocks)	0.250

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TECHNICAL REPORTS

Atmospheric Pollutants and Trace Gases

Ammonia emissions and dispersion from broiler production

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Funding information
US Poultry and Egg Association

Abstract

Ammonia (NH_3) has been used as a target gas for nuisance complaints to restrict or close poultry operations near encroaching rural development. There are conflicting data on NH_3 emissions from broiler production across the United States. The purpose of this research is to compare emission rates from a Georgia broiler operation across seasons and with other geographical areas in the United States. Comparison of seasonal and geographical emission rates showed large seasonal variation in NH_3 emissions for eastern U.S. sites but little seasonal variation in the semi-arid region of the United States. Differences in production management practices, ambient temperature, and animal density did not appear to explain differences in emissions between regions; however, the climatic influence of ambient humidity and litter management practices are thought to be key factors in the generation of emissions.

1 | INTRODUCTION

The perception of odor and ammonia (NH_3) from poultry production facilities is often a source for complaints against poultry producers and poultry companies (Ritz et al., 2004). Pressure from environmental and community groups has resulted in an increasing number of nuisance complaints and legal actions that attempt to restrict poultry operations based on assumptions of large emissions of NH_3 affecting local environments.

Ammonia is a natural by-product of animal manure decomposition. Ammonia alone is not considered a criteria air pollutant by the Clean Air Act; however, it is a precursor of secondary particulate matter smaller than 2.5 μm ($PM_{2.5}$), which is listed by the USEPA as a criteria air pollutant (Harper, 2005). In the atmosphere, NH_3 is the only significant basic gas; thus, it has an important role in the neutralization of atmospheric acid gases generated by the oxidation of sulfur dioxide (SO_2) and nitrogen oxides (NO_x). As a result of the neutralization reaction, ammonium (NH_4^+) salts are formed, which are a major component of atmospheric aerosols found in precipitation (Asman et al., 1998). Other organic forms of nitrogen (N) also exist, such as amines and organic N compounds, but the concentrations of these components are generally negligible by comparison (Van der Eerden, 1982). Most NH_3 emitted globally is of anthropogenic origin (Bouwman et al., 1997), from agricultural production in general (animal feeding operations in particular), and from automobiles in regions of high human population (Sun et al., 2017). Agricultural sources may be numerous and may be scattered both temporally and spatially; however, confined animal production tends to be concentrated in relatively small geographical areas and may increase N loading in these areas (Harper et al., 2009).

Although research on NH_3 and other gas dispersion and transport has been conducted in swine, beef, and dairy operations (Harper et al., 2004, 2009, 2010a), there is insubstantial data from poultry housing. Such data would be beneficial

Abbreviations: IDM, Lagrangian inverse-dispersion methodology.

TABLE 2 Calculated end-of-flock ammonia emissions (last 4 wk) from broiler houses by season

State (study)	Season	Measurement technique	Measurement period (age of flock)	Bird density	Ammonia emissions (last 4 wk)
			d	birds m^{-2}	g NH_3 $bird^{-1}$ d^{-1}
Pennsylvania[a] (Wheeler et al., 2006)	summer[b,c]	air mass-balance	21–42	14.6	2.14
Georgia (this study)	summer[b,c]	bLS[d]	31–52	12.6	1.31 ± 0.13
Kentucky[a] (Wheeler et al., 2006)	summer[b,c]	air mass-balance	28–49	13.4	1.31
Kentucky[a] (Burns et al., 2007)	summer[b,c]	air mass-balance	24–50	12.0	1.09
Texas (Lacey et al., 2003)	summer[b,e]	air mass-balance	28–49	13.5	1.05
Arkansas[a] (Moore et al., 2011)	summer[b,f]	air mass-balance	21–42	15.8	0.92
California (Cortus et al., 2010)	summer[c,g]	air mass-balance	26–47	10.0	0.63
California (Harper et al., 2010b)	summer[c,g]	bLS	26–47	10.0	0.52
California[a] (Summers, 2005)	summer[c,h]	air mass-balance	24–45	14.7	0.24
Pennsylvania (Wheeler et al., 2006)	winter[b,i]	air mass-balance	21–42	14.6	1.04
Kentucky[a] (Wheeler et al., 2006)	winter[b,c]	air mass-balance	28–49	13.4	0.78
Georgia (this study)	winter[b,c]	bLS	31–52	13.4	0.69 ± 0.07
California (Cortus et al., 2010)	winter[c,g]	air mass-balance	26–47	10.8	0.78
California (Harper et al., 2010a)	winter[c,g]	bLS	26–47	10.8	0.46
Arkansas[a] (Moore et al., 2011)	winter[c,h]	air mass-balance	28–49	12.8	
Kentucky[a] (Burns et al., 2007)	winter[b,c]	air mass-balance	26–50	12.6	

[a]Estimated from tables, relationships, and graphs in the publications. [b]Wood shavings bedding. [c]Litter conditions: third flock, bu
Lagrangian inverse dispersion analysis (bLS, WindTrax software). [e]Litter conditions: second flock, built-up litter. [f]First flock aft
conditions: fourth flock, built-up litter. [i]Litter conditions: fifth flock. built-up litter.

TABLE 4 Comparison of NH_3 emissions between geographical areas and litter types

Study	Location	Litter conditions	Ammonia emissions
			kg NH_3 $bird^{-1}$ yr^{-1}
Demmers et al., 1999	United Kingdom (Europe)	new litter[a]	0.030
Nicholson et al., 2004	United Kingdom (Europe)	new litter[a]	0.040
Müller et al., 2003	Germany (Europe)	new litter[a]	0.016
Harper et al., 2010b	California (western U.S.)	new litter[b,c]	0.099
Harper et al., 2010b	California[d] (western U.S.)	new litter[b,c]	0.118
Wheeler et al., 2006	Pennsylvania (eastern U.S.)	built-up[a,e] (two to four flocks)	0.150
Wheeler et al., 2006	Kentucky (middle U.S.)	built-up[a,e] (two flocks)	0.205
Burns et al., 2007	Kentucky (middle U.S.)	built-up[a,e] (two flocks)	0.230
Moore et al., 2011	Arkansas (southern U.S.)	built-up[a,e] (one to two flocks)	0.250
Lacey et al., 2003	Texas (southern U.S.)	built-up[a,e] (new litter to one flock)	0.180

[a]Wood shavings. [b]New litter on brood end (one-half of house) area and 7 cm new litter on top of remaining litter. [c]Rice hulls. [d]These emissions include the flock-period plus the period of clean-out, stockpiling of removed litter, removal of litter, and the empty down-time between flocks. [e]pH-reducing treatment applied.

TABLE 5 Plume NH_3 concentration dispersion during the last 4 wk of the flock production cycle in humid East and semi-arid West poultry operations

Location	Season	Daily average	Nighttime average	Daytime average
		μl L^{-1} ± SD		
Humid east	summer	0.45 ± 0.11	0.50 ± 0.13	0.44 ± 0.10
Humid east	winter	0.15 ± 0.05	0.16 ± 0.05	0.15 ± 0.04
Semi-arid west	summer	0.07 ± 0.04	0.10 ± 0.01	0.04 ± 0.02
Semi-arid west	winter	0.10 ± 0.08	0.14 ± 0.04	0.09 ± 0.04

Evaluation of Emission Control technologies

- Ionization
- Bedding-free system

Improving In-House Air Quality in Broiler Production Facilities Using an Electrostatic Space Charge System

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Primary Audience: Broiler Production Managers, Poultry Producers, Researchers

SUMMARY

Reduction of airborne dust in enclosed animal housing has been shown to result in corresponding reductions in airborne bacteria, ammonia, and odor. The search for strategies to reduce particulate matter and ammonia emissions from animal housing has led to considerable interest in the poultry industry for practical systems to reduce these air emissions. Technologies that have been shown to be effective for reducing airborne dust in animal areas include misting with an oil spray, water mists, extra ventilation, and electrostatic space charge systems. An electrostatic space charge system (ESCS) was designed to reduce airborne dust and ammonia emissions from a commercial broiler production house. The ESCS for this application was based on patented technology developed to reduce airborne dust and pathogens. Two commercial broiler houses with built-up litter (a control house and one outfitted with an ESCS unit) were monitored for dust and ammonia concentrations over a period of 7 flocks. Results of this study indicate the ESCS significantly reduced airborne dust by an average of 43% and reduced ammonia by an average of 13%. Power consumption of the ESCS system was less than 100 W when in operation. Commercial application of this technology within the production house has the potential to improve in-house air quality and reduce particulate emissions.

Key words: electrostatic, ionization, poultry, dust, ammonia

2006 J. Appl. Poult. Res. 15:333–340

DESCRIPTION OF PROBLEM

Air quality relating to poultry production housing has been a major concern for years, particularly with regard to poultry health. Environmental concerns and nuisance issues related to poultry house air emissions are now issues affecting the poultry industry. Of specific concern are ammonia, particulate matter, and odor. Although there is considerable research directed at defining the problem and scope of emissions, it is equally important that practical and economical control measures be examined.

Dust concentrations in poultry houses have been reported to vary from 0.02 to 81.33 mg/m^3 for inhalable dust and from 0.01 to 6.5 mg/m^{3}for respirable dust [1]. Sources of dust in broiler

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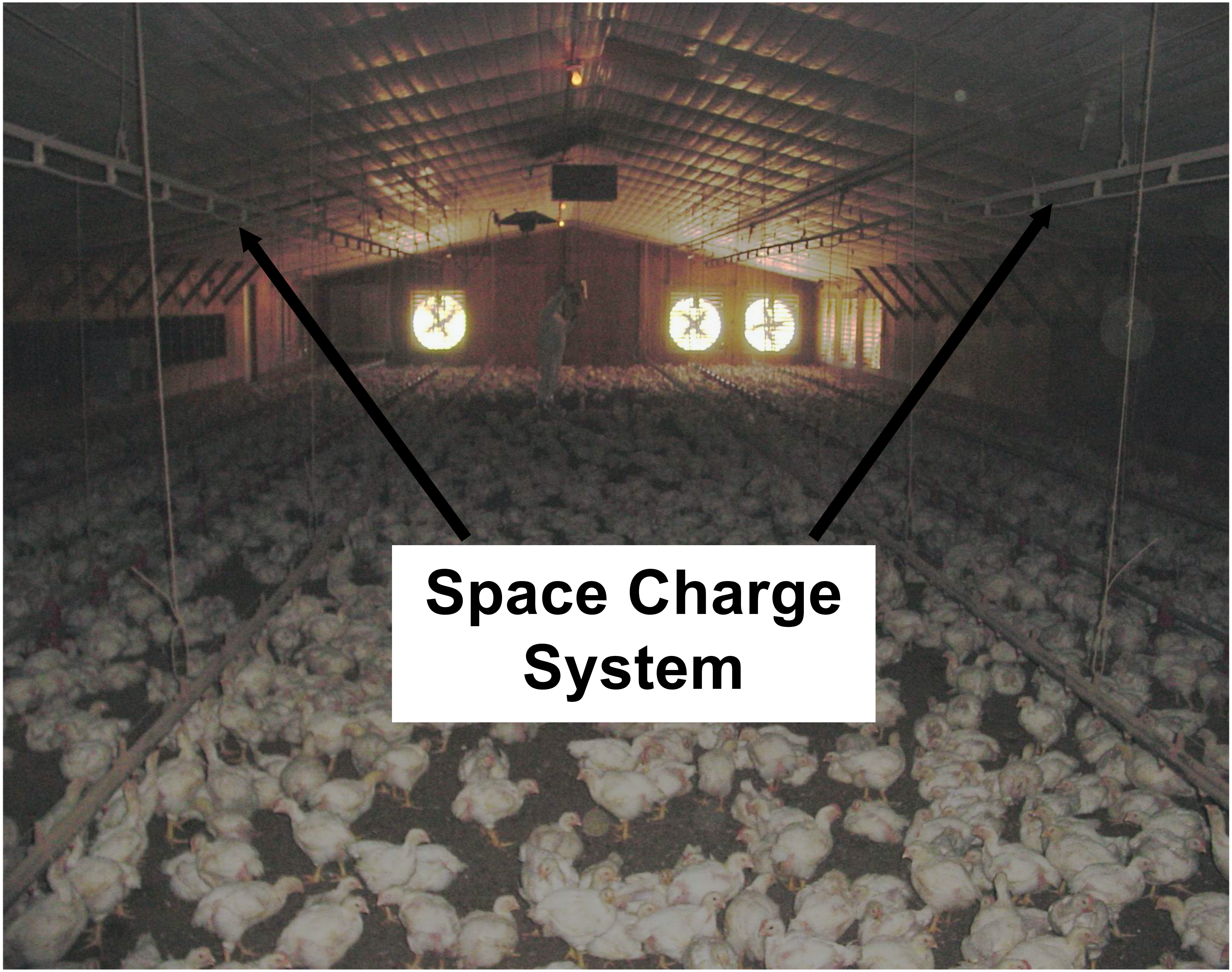
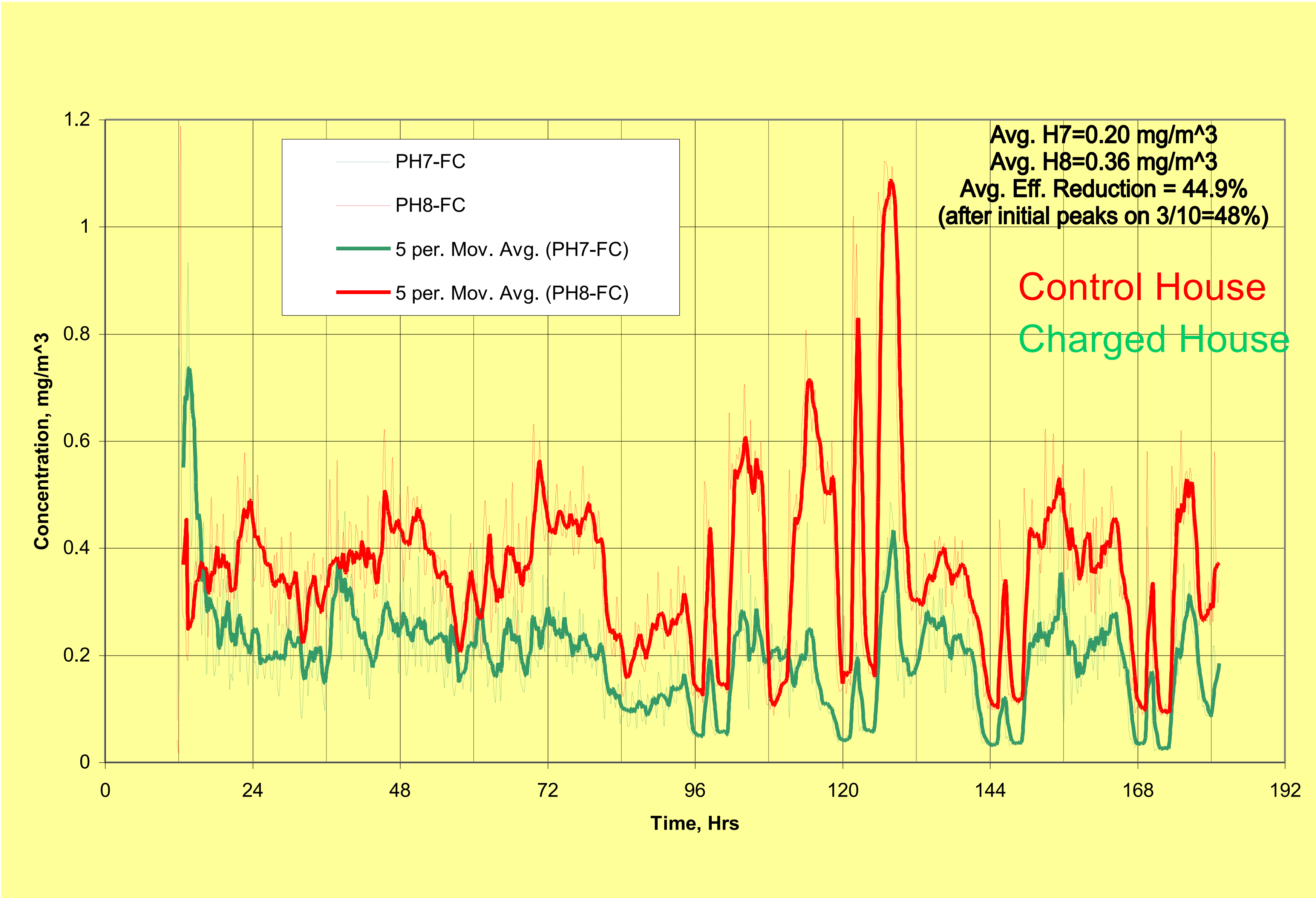
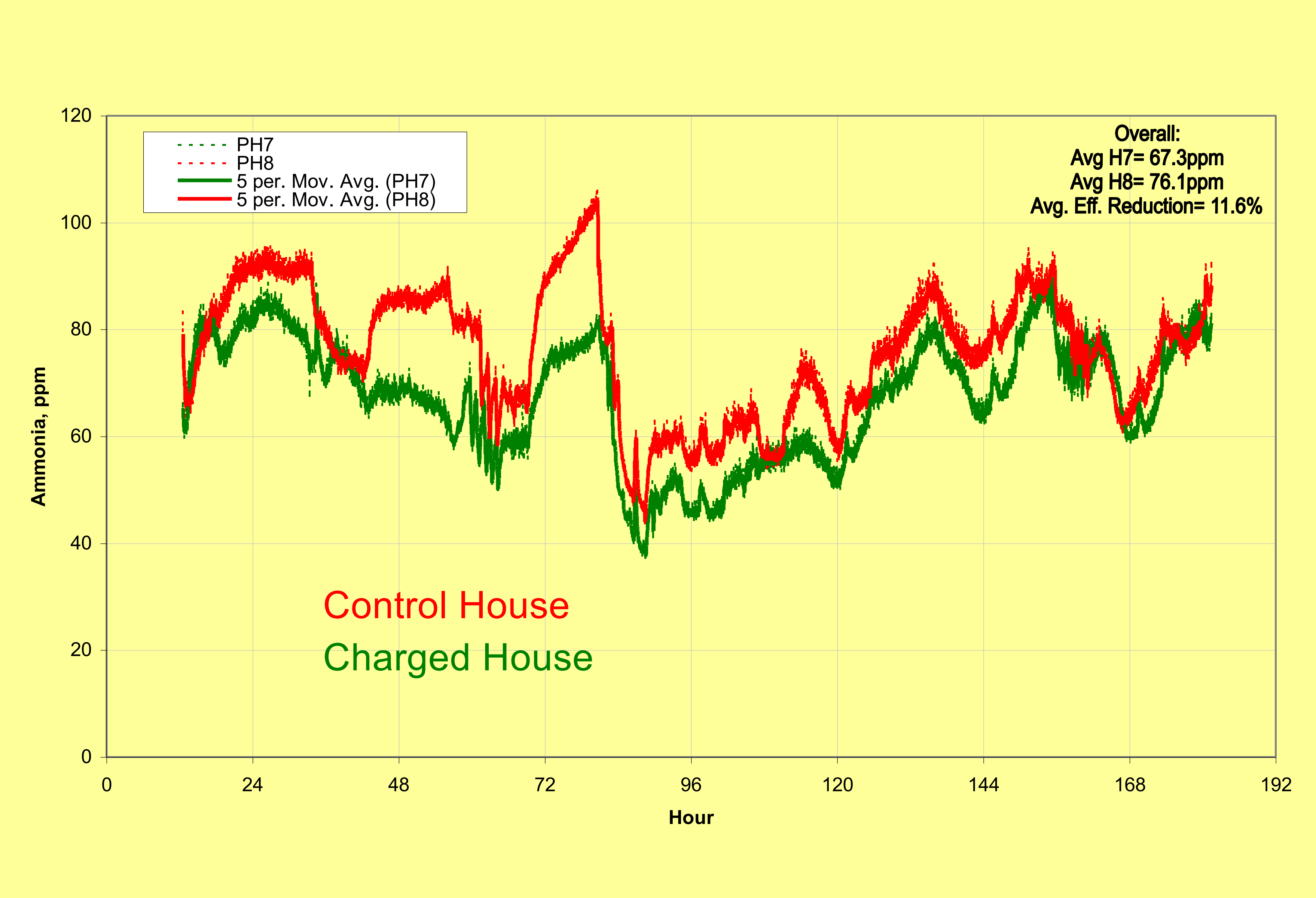

Space Charge System

Dust Level Comparison



Ammonia Level Comparison



THE UNIVERSITY OF GEORGIA

POULTRY
Environmental Management & Energy Conservation

Search

Broiler House Flooring System

Principal Investigator: Dr. Casey Ritz

Contact Email: critz@uga.edu

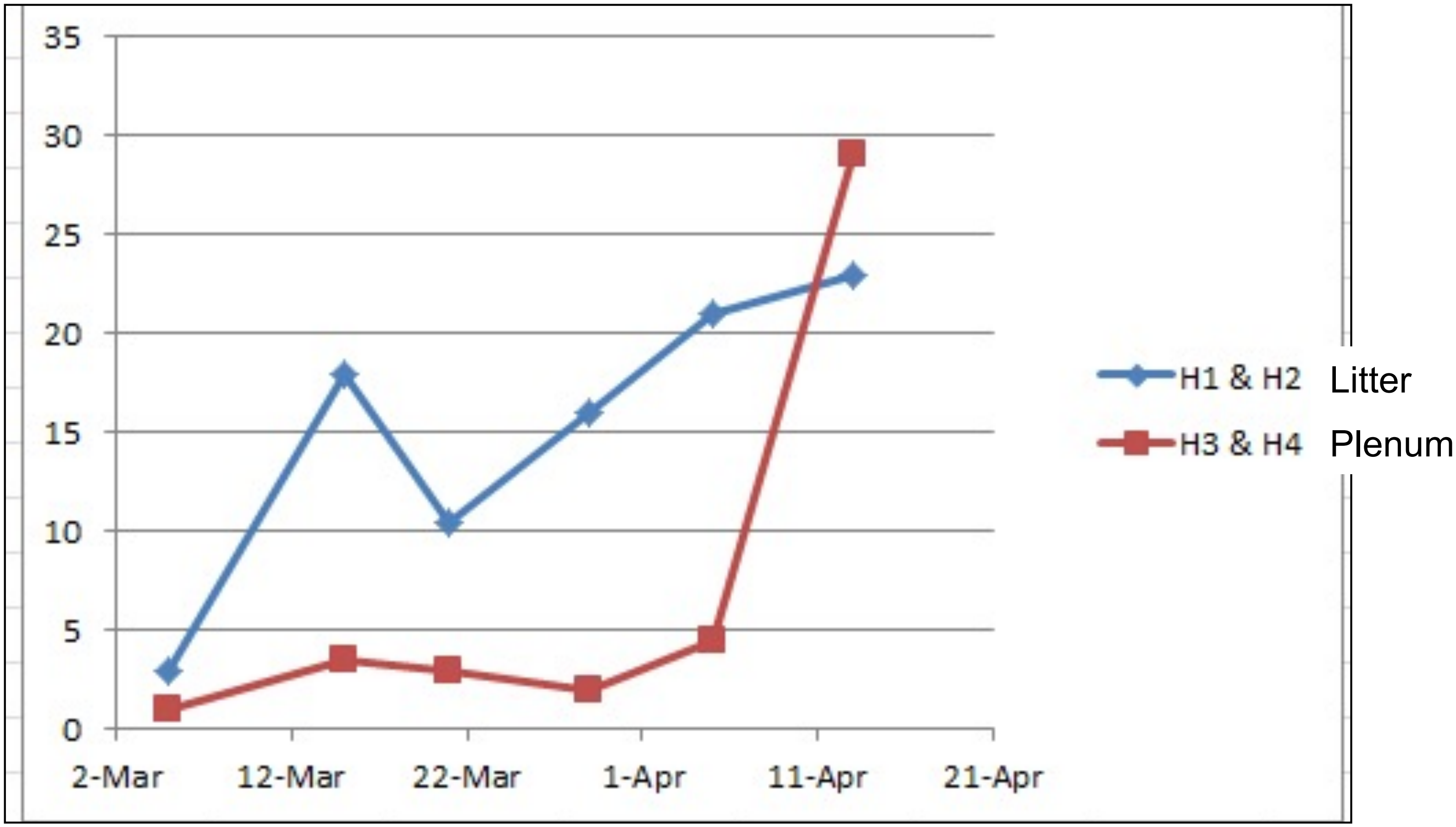
Environmental Benefits in Poultry Houses through use of a Plenum Flooring System. Conservation Innovation Grant Program (USDA)

AviHome, LLC - March, 2011

1. **Project Background**

We are proposing to demonstrate an innovative and highly effective floor for reducing ammonia emissions in chicken houses. Approximately 9 billion broilers (chickens raised for meat production) are raised in the United States (US) annually producing 25 billion pounds of manure. Broiler house floors have several types of material that is used to absorb/ dilute the manure moisture. In the broiler houses ammonia is produced by a natural chemical reaction in the feces and released which is detrimental to the environment, broiler health and human health. After many years of engineering and testing, special flooring has been developed by AviHome to replace the litter as the base of the floor to rear broilers.

Ammonia concentration (ppm)



Emission Summary: Critical factors

- Accuracy of measurement technology
- Accuracy of modeling
- Regional variance and impact of geographic and atmospheric influence
- Industry practices, market targets, company policies and procedures
- Emission control technology impact on animal welfare and sustainability