Overview of Ammonia Mitigation BMPs and BATs

Hongwei Xin, Professor

Iowa State University

An OSU Ammonia Workshop Presentation

May 2, 2011, Columbus, OH

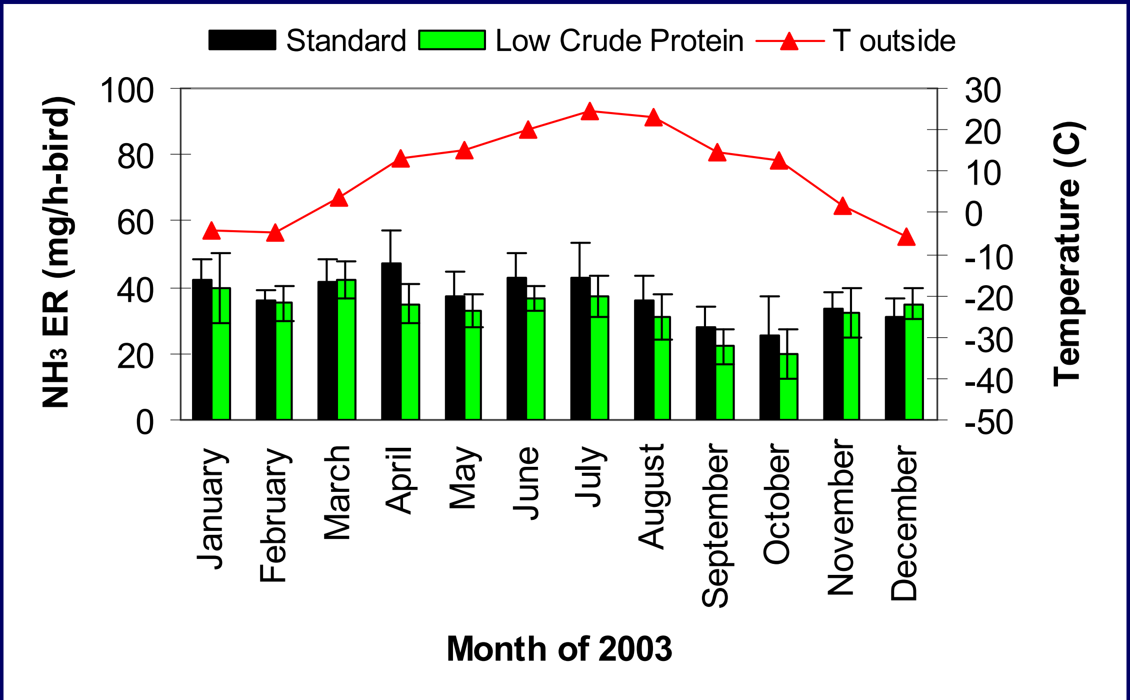
Sources of NH_3 Mitigation

- **Pre-excretion**
  - ✓ **Dietary manipulation**
  - ✓ Feed or water additives
  - ✓ Genetics
- **Post-excretion**
  - **Housing and manure handling schemes**
  - **Indoor treatment (to reduce generation)**
  - **Exhaust treatment (to reduce emission)**

Pre-excretion Mitigation

Dietary Manipulation

Effect of Reducing CP Content on NH_3 Emission of High-Rise Layer Houses

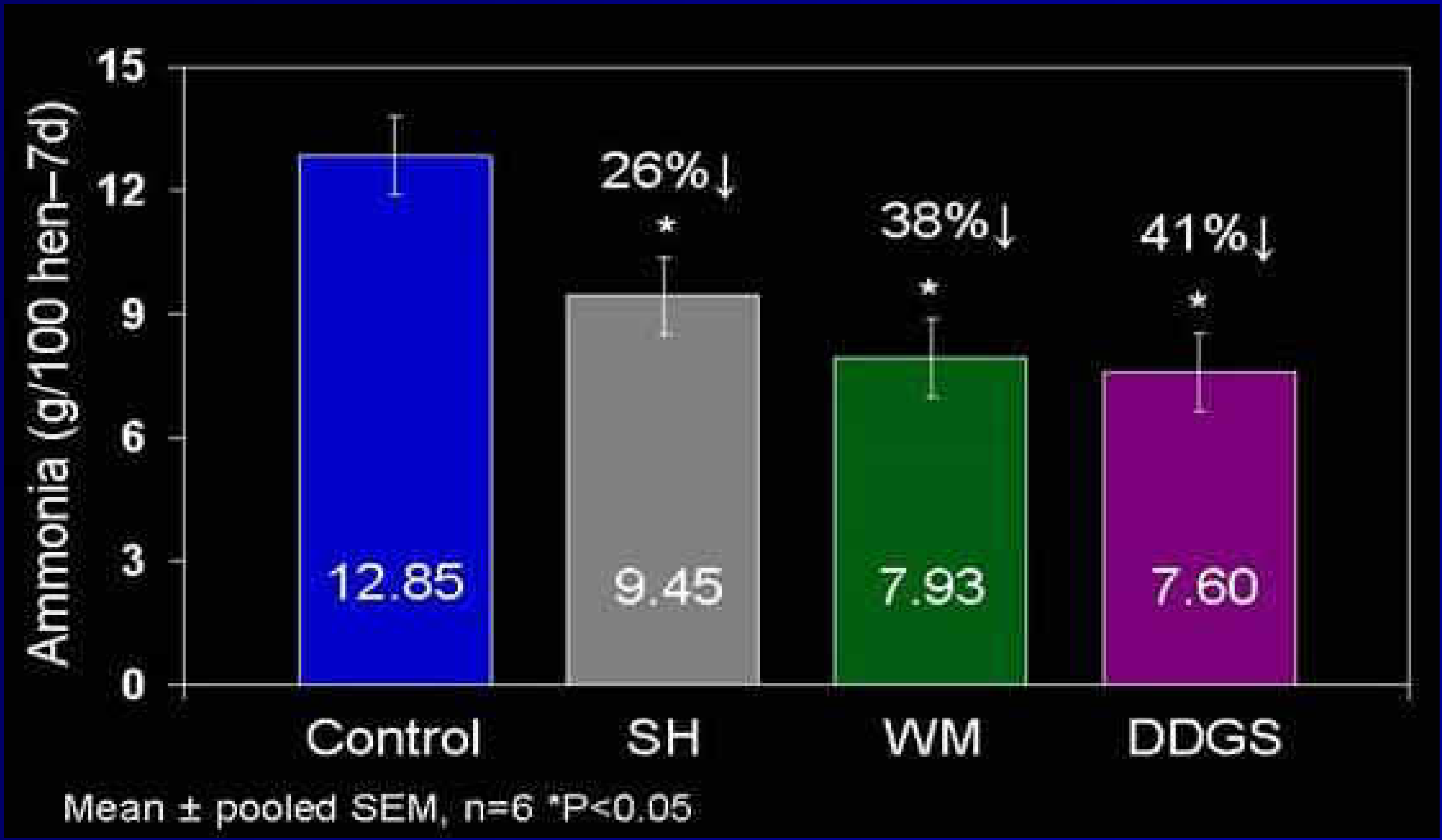


NH_3 ER (g/hen-d)	
Standard Diet	**LP Diet**
0.90 (0.24-1.58)	**0.80** (0.19-1.37)

- 1% lower dietary CP → 11% reduction in NH_3 emission

Liang et al., (2005)

Effect of Adding Dietary Fiber on NH_3 Emission from Layer Manure



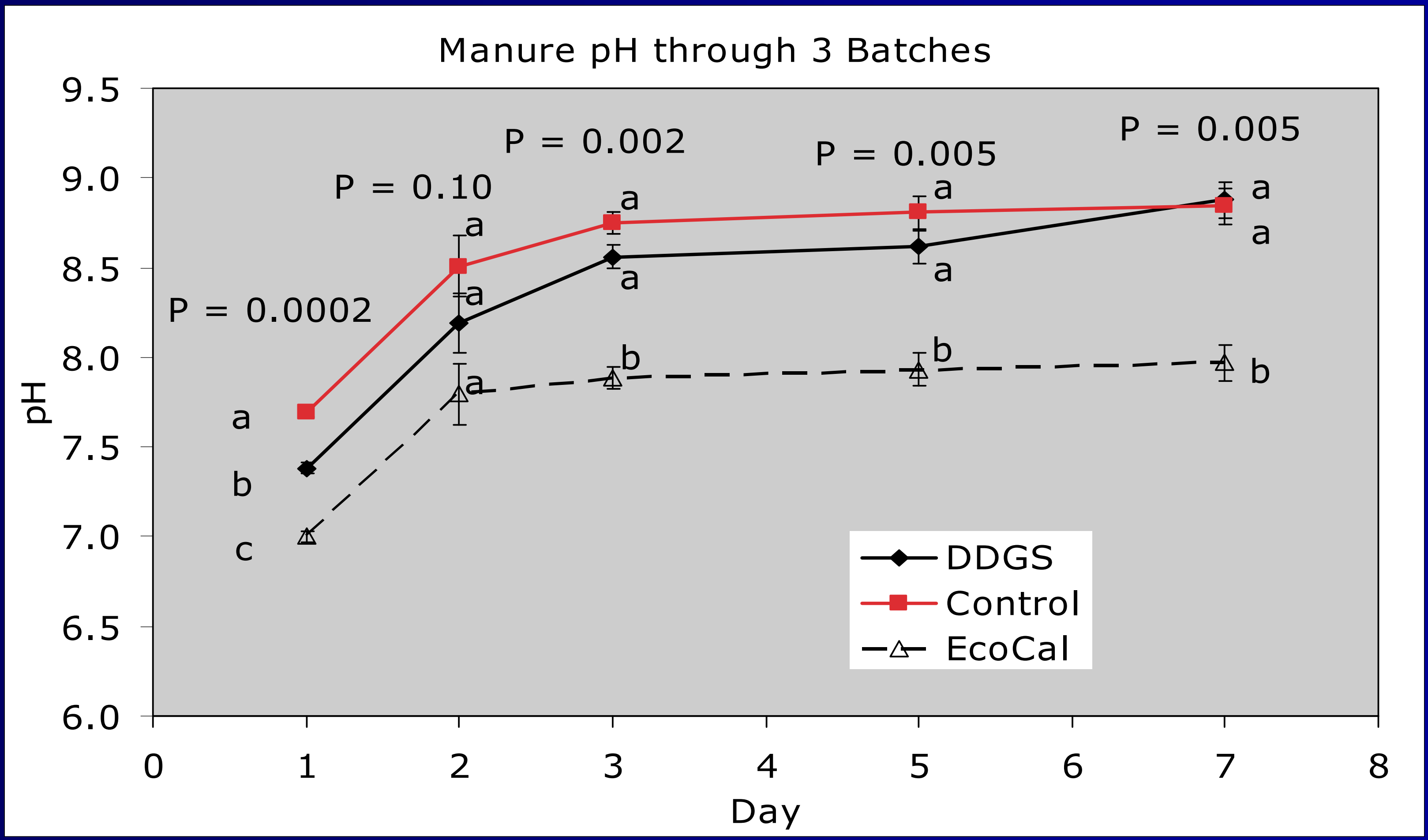
Roberts et al. (2007)

24-month Data of NH_3 & H_2S Emissions of H-R Layer Houses Fed Different Diets

Gas & change	Control	DDGS	EcoCal
NH_3, g/hen-d	0.96 (0.05)	0.82 (0.05)	0.58 (0.05)
% reduction	--	14 (5)	39 (5)
H_2S, mg/hen-d	1.79 (0.16)	1.99 (0.13)	5.39 (0.46)
% increase	--	12 (10)	202 (45)

Xin et al. (2001, Unpublished data)

Manure pH of Hens Fed Three Diets

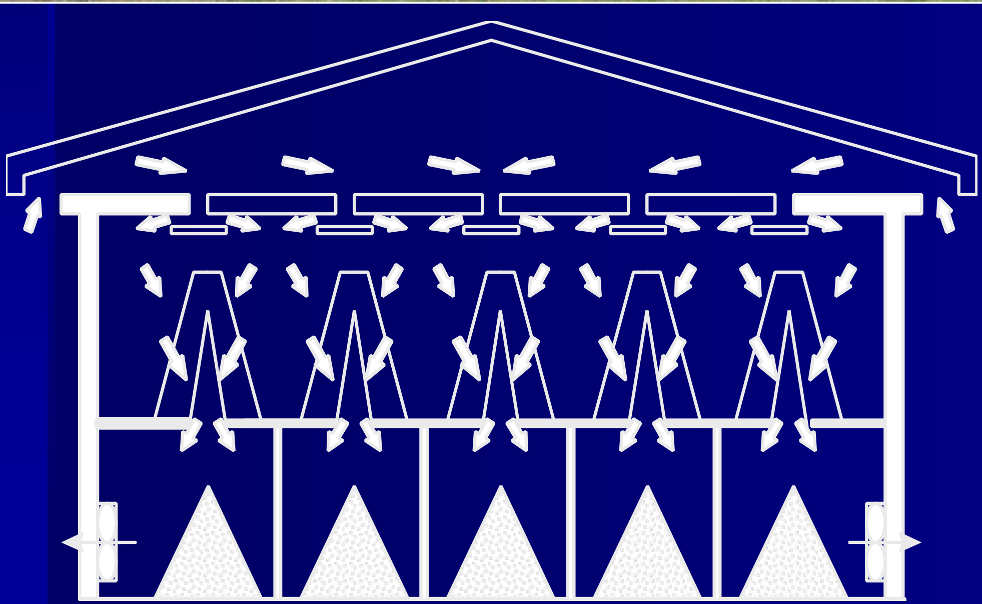


Xin et al. (2010, Unpublished data)

Post-excretion Mitigation

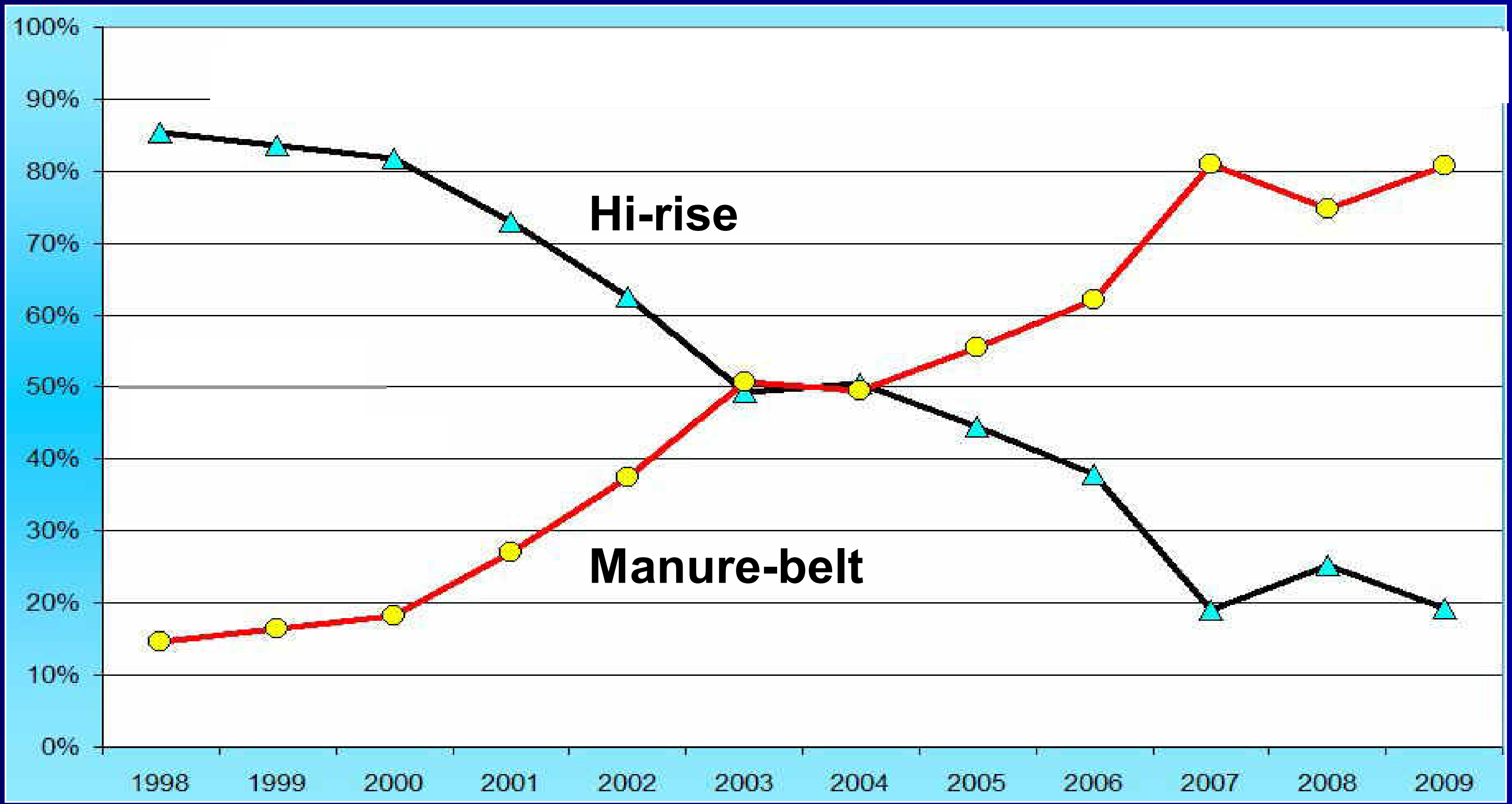
Housing and Manure Handling Schemes

High-Rise Hen House



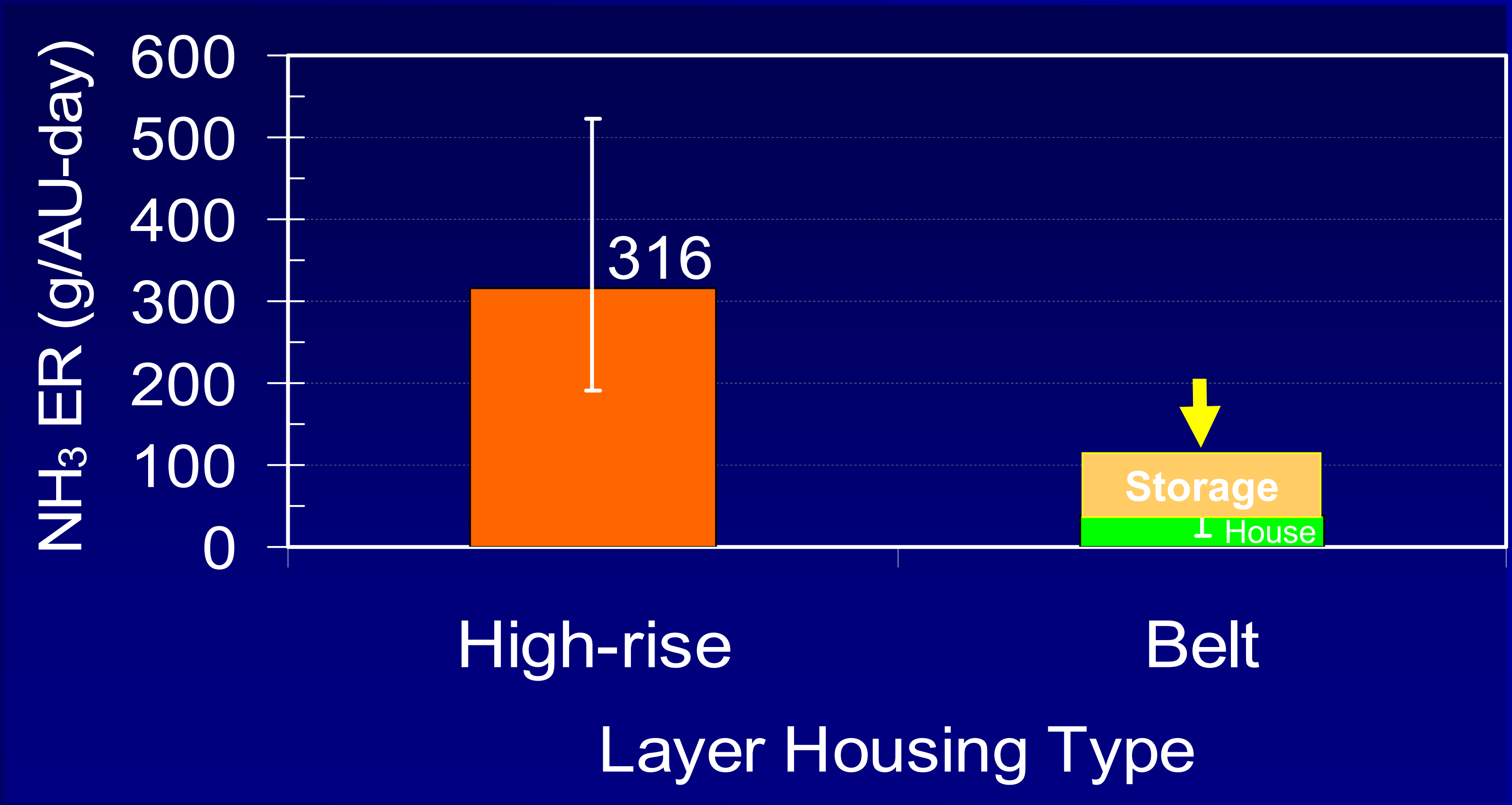
Manure-Belt House + Manure Storage

U.S. Trend in Layer Cage Systems



Courtesy of Tom Lippi, CTB

High-rise vs. Manure Belt Layer House NH_3 Emission Rate

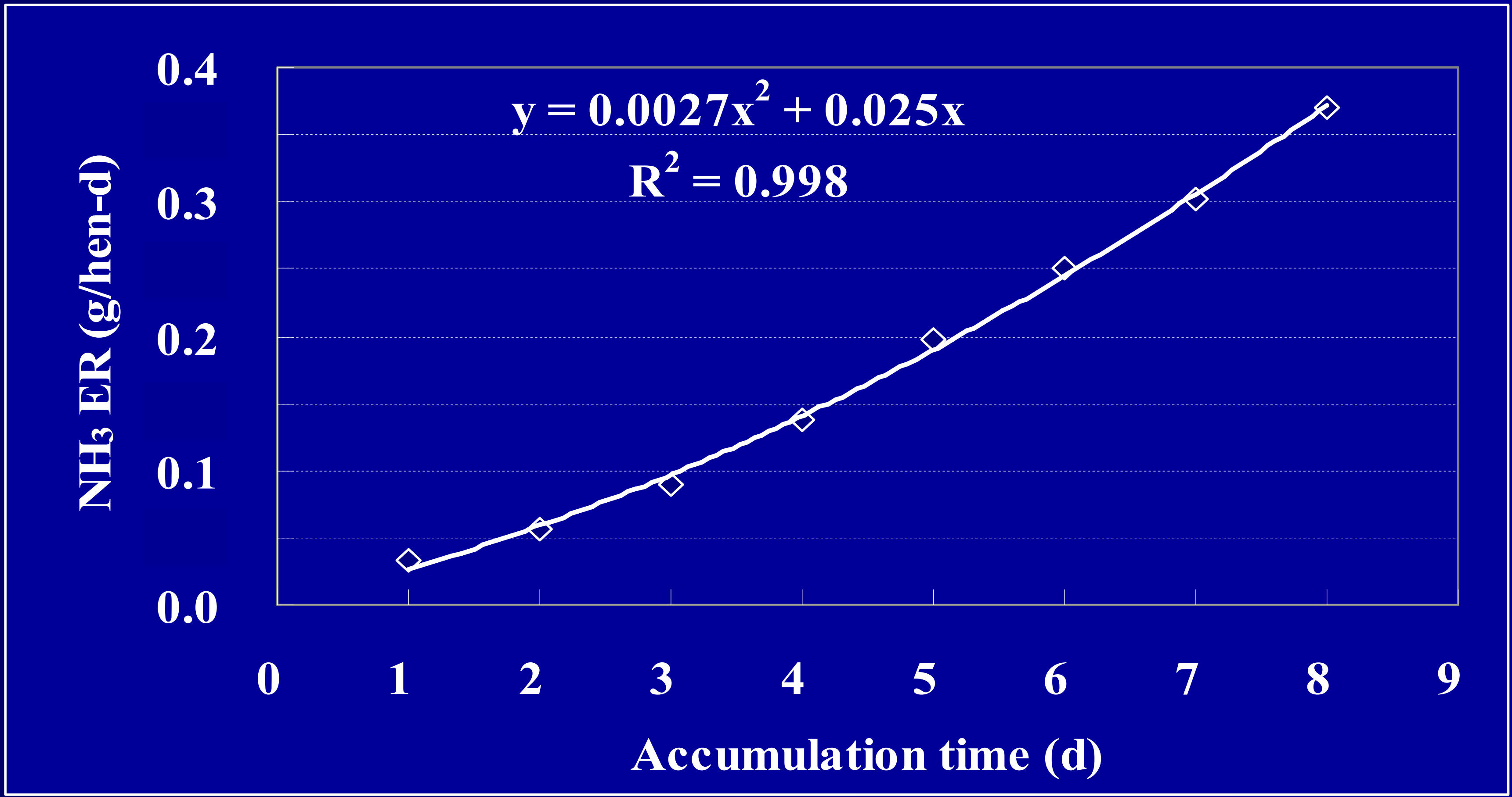


AU = animal unit = 500 kg live body weight

Factors Contributing to Lower Emissions of MB Systems

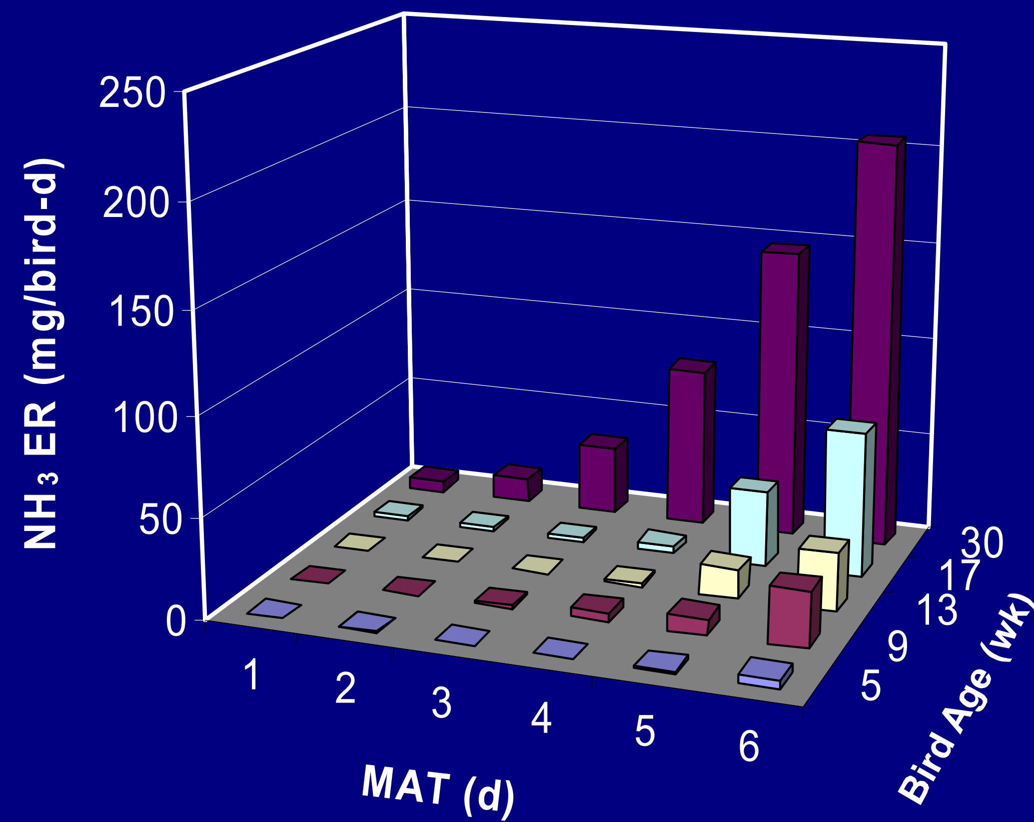
- Reduced manure residence time and hence its decomposition in the hen house
- Reduced emission surface area in storage
- Generally cooler environment in storage
- Drying manure

NH_3 Emission *(g/hen-d)* vs. Hen Manure Accumulation Time



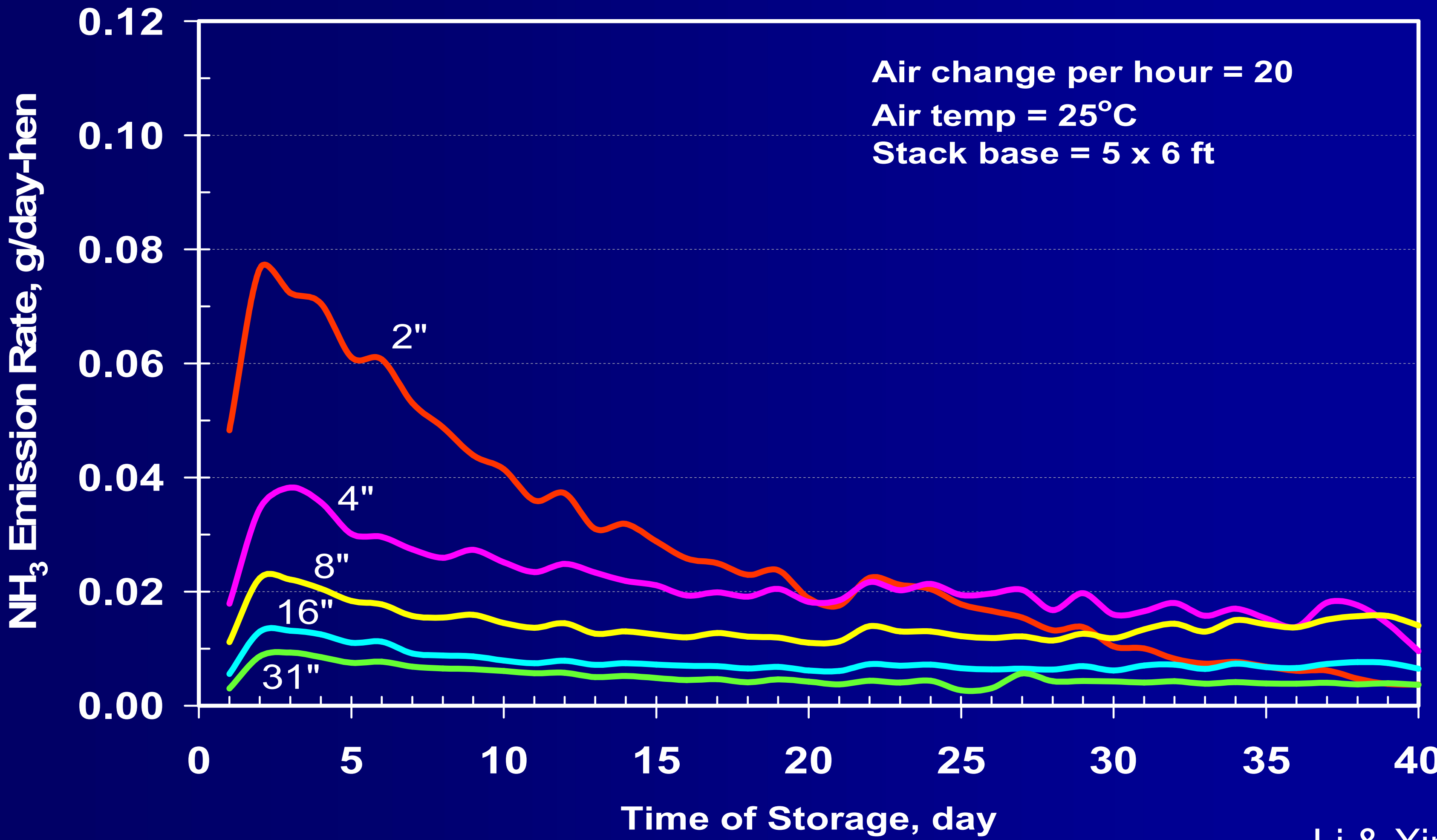
Ning – ISU (2008)

NH_3 Emission *(g/bird-d)* vs. Manure Accumulation Time at Different Ages



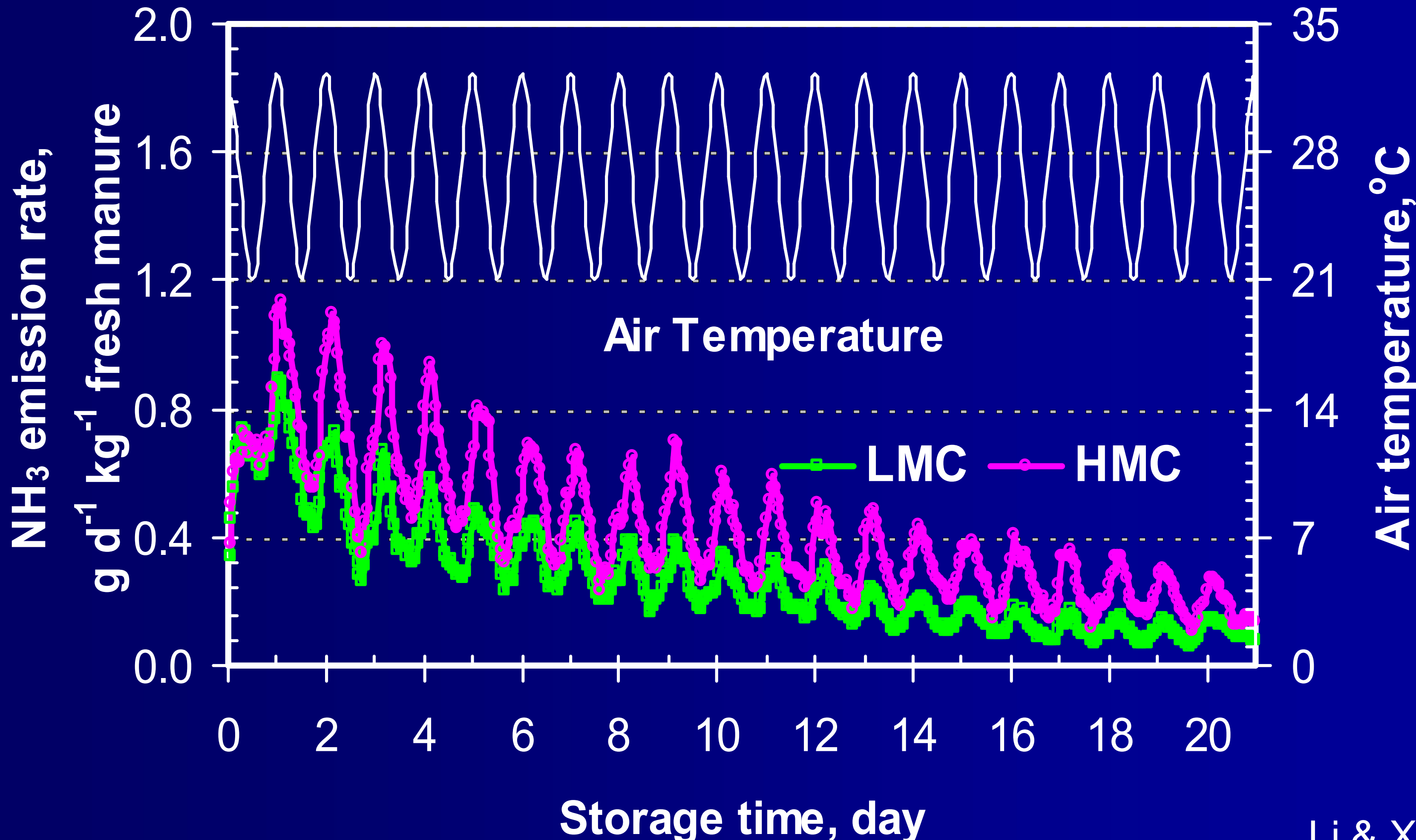
Mendes – ISU (2010)

Effect of Stacking Configuration on NH_3 Emissions from Hen Manure Storage



Li & Xin (2010)

Effects of Hen Manure Moisture & Air Temperature on NH_3 Emission

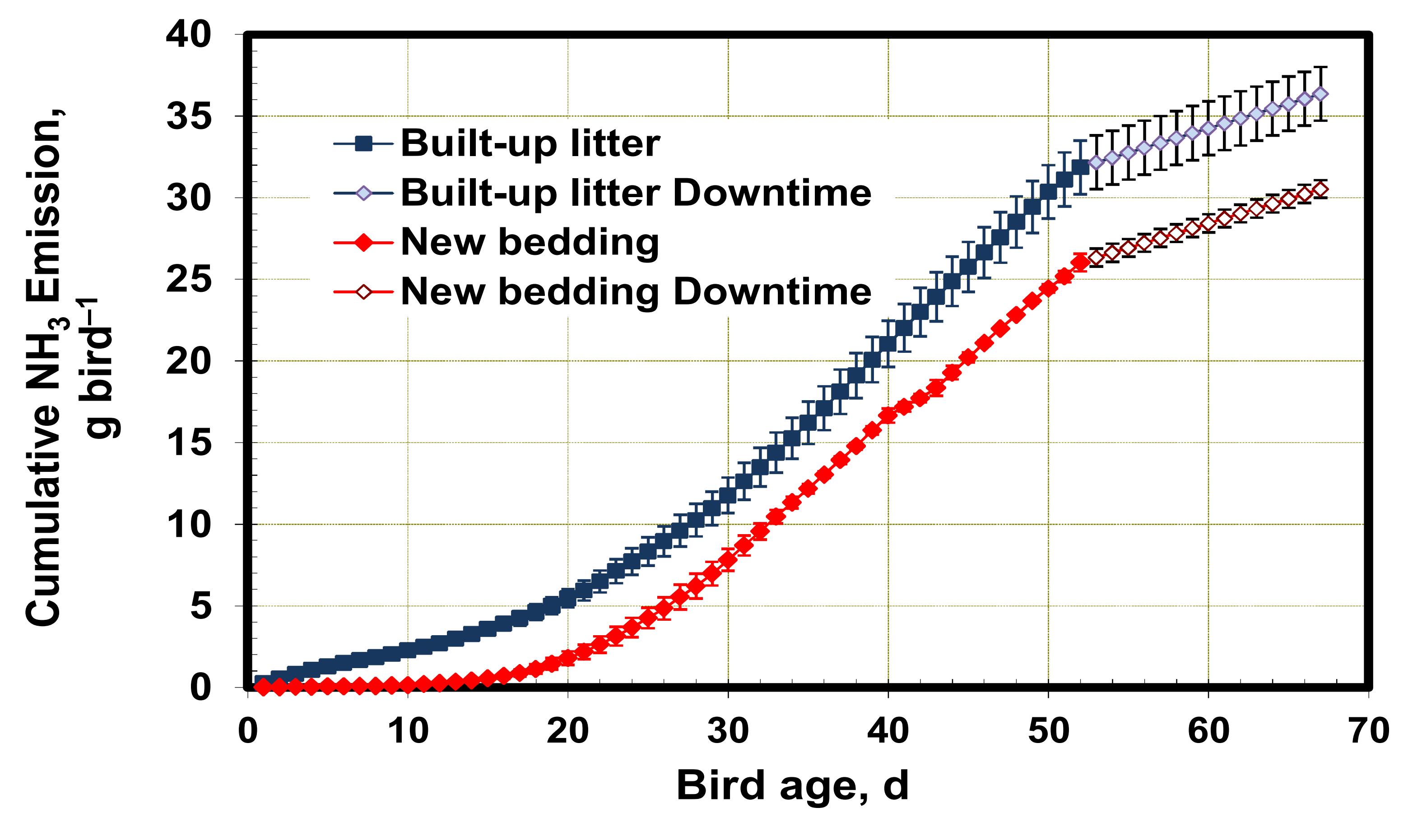


Li & Xin (2010)

Some Practical Aspects of Manure-Belt Layer Systems

- Higher construction costs (~50% more)
- Potentially higher maintenance needs due to longevity of manure belt and conveying system
- Need of separate manure storage facility

New *vs.* Built-Up Litter of Broiler Houses on NH_3 Emissions



Burns et al. (2007)

Factors to Consider in Using New vs. Built-Up Litters

- Availability and price of bedding materials
- Higher energy cost helps offset high price of bedding, hence may justify its use every flock.
- Improved bird health and performance
- Built-up litter requires more ventilation to control NH_3 level – likely increase emissions.
- Break-even LP gas price in 1992 was $0.75/gal. Analysis based on current pricing is needed.

Post-excretion Mitigation

Indoor Treatment to Reduce NH_3 Generation

Manure/Litter Additives

- Natural zeolite $[(Na_4K_4)(Al_8Si_{40})O_{96}\cdot 24H_2O]$
  - Adsorption of NH_4^+
- Acidulants (low pH)
  - Alum (aluminum sulfate)
  - Ferix-3 (ferric sulfate)
  - Poultry Litter Treatment or PLT (sodium bisulfate)

Zeolite

Liquid Alum

Solid Alum

Ferix-3

PLT

Reduction of NH_3 Emission from Stored Hen Manure by Topically Applied Additives

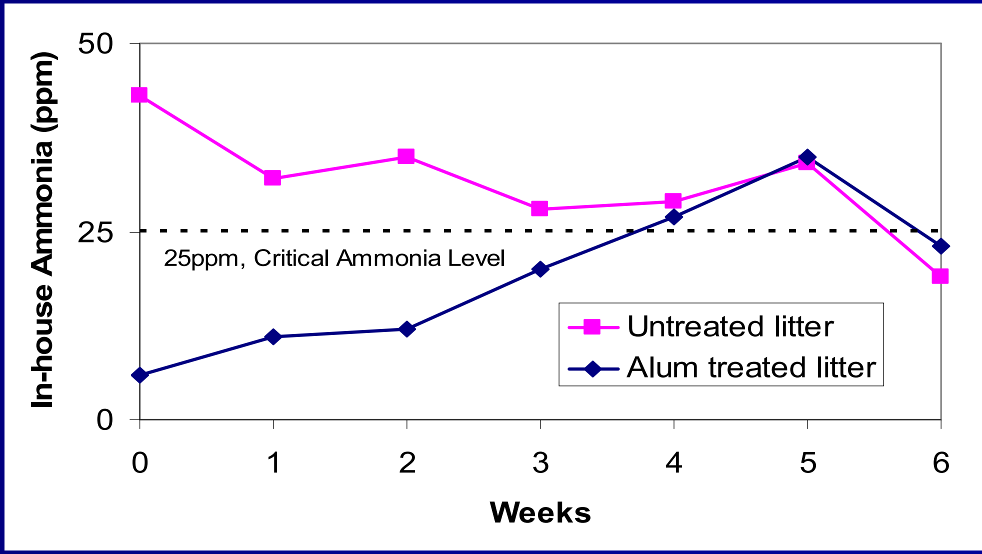
Additives	Application dosage		
	Low	Medium	High
Zeolite	68%	81%	96%
Liquid Alum	63%	89%	94%
Alum Powder	81%	93%	94%
Ferix-3	82%	86%	87%
PLT	74%	90%	92%

Reduction based on single application over a 7 day period

Li et al. (2008)

Topical Application of Chemical Additives in Broiler Systems

e.g., 100 – 200 lbs alum per 1000 ft^2 floor area recommended; with lower dosage lasting ~ 2 wk and hi dosage ~ 3 wk



Moore et al. (2000)

Some Practical Issues with Chemical Applications

- Corrosive nature of the low pH chemicals necessitates caution in applicator health/safety and housing equipment protection (e.g., fans).
- Must be re-applied to between flocks to maintain effectiveness.

Post-excretion Mitigation

Treatment of Animal Housing Exhaust Air

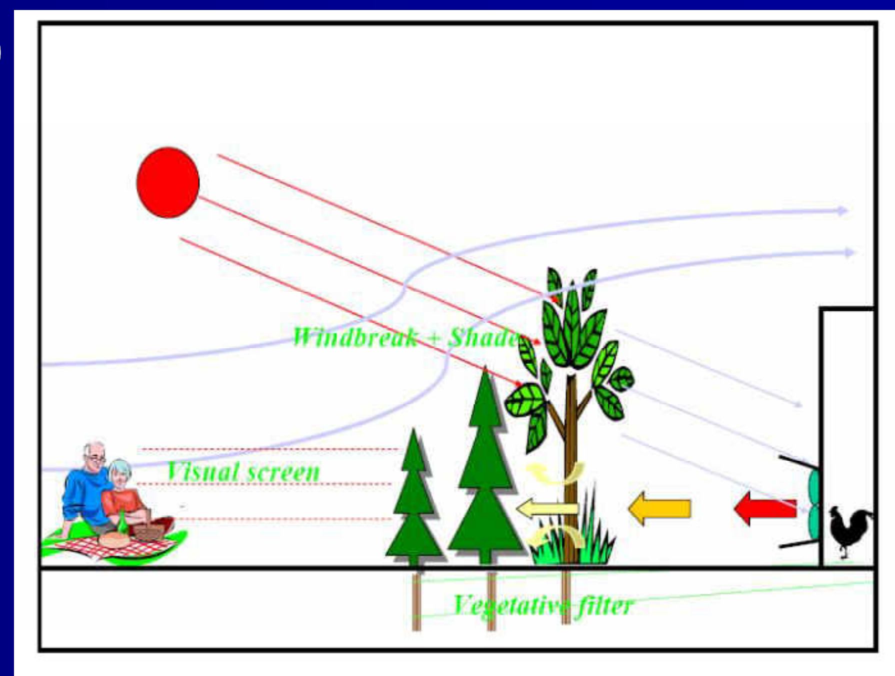
Exhaust Air Treatment Systems

- Dispersive Systems with some treatment
  - Vegetative Buffers
  - Windbreak Walls
  - Biomass Walls & Bio Curtains
- Exhaust Air Treatment Systems
  - Biofilters
  - Single Stage Biological Scrubbers
  - Single Stage Acid Scrubbers
  - Multi-Stage, Multi-pollutant Scrubbers

Vegetative Environmental Buffer

Data reported from a broiler house in DE:

- **PM reduction: 49±27% (33 d)**
- **NH_3 reduction: 46±31% (29 d)**
- **Odor reduction: negligible**



Malone et al. (2006)

Biocurtains or Biomass Wall

Reduce dust emissions by 17-20% from poultry houses. Cost ~ $5000 per tunnel-ventilated house

Cornstalk or straw wall traps dust, reducing odor 40-90% from swine or poultry facilities (Dong et al., 2002)

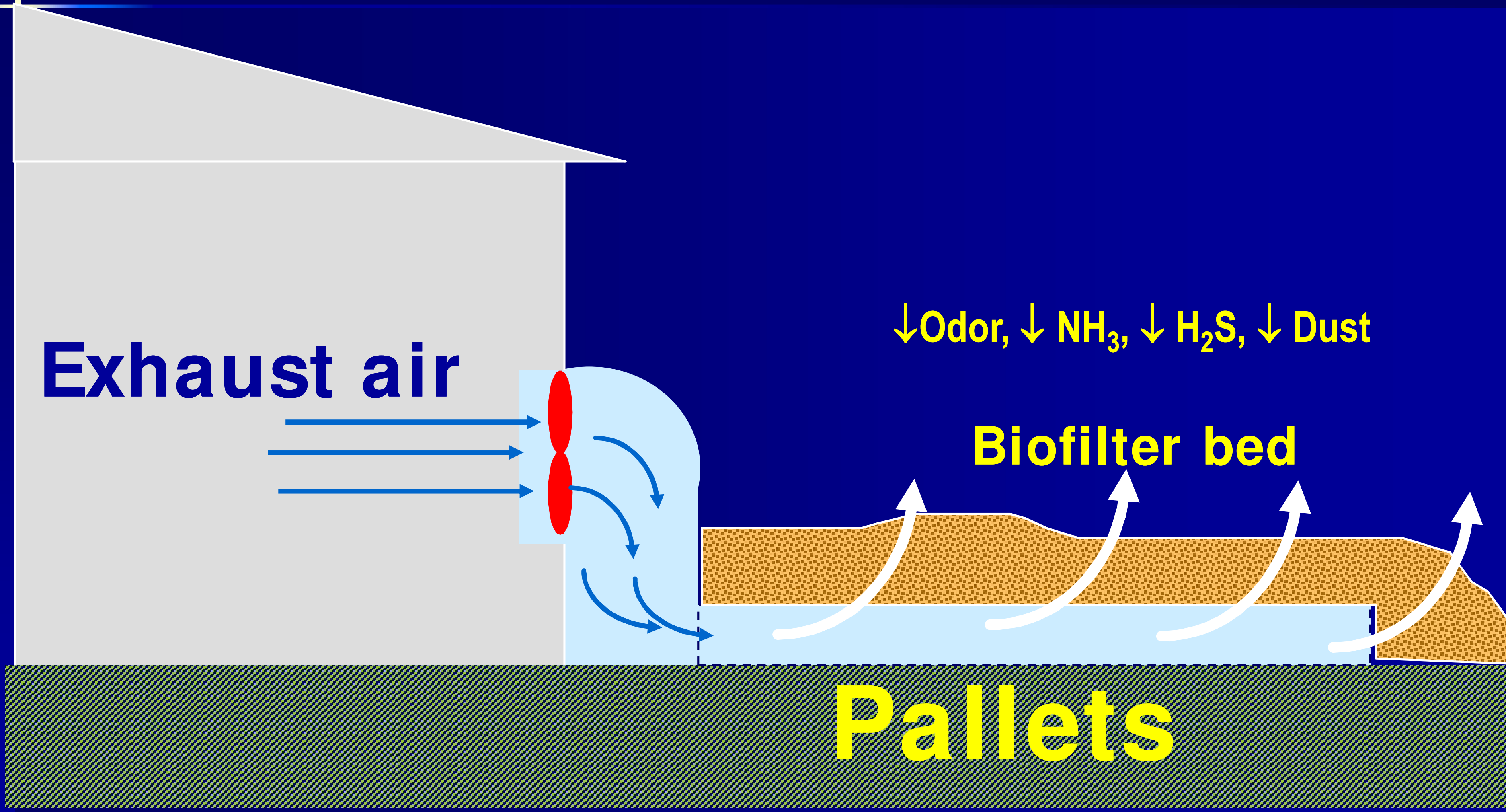
Bio-filters and Scrubbers

- Biofilters provide good odor control but limited ammonia control.
- Acid scrubbers provide good ammonia control but limited odor control.
- Multi-stage units that include an acid scrubber and a biofilter component can provide both odor and ammonia control.

Biofilters

- Have been used for odor control of swine houses in Germany for 20+ years (Oldenburg Biofliters)
- Have been researched and demonstrated in the US for more than a decade (Nicolai, Jacobson, Hoff, and others)

Open-faced Biofilter System



Biofilter on a German Swine Farm

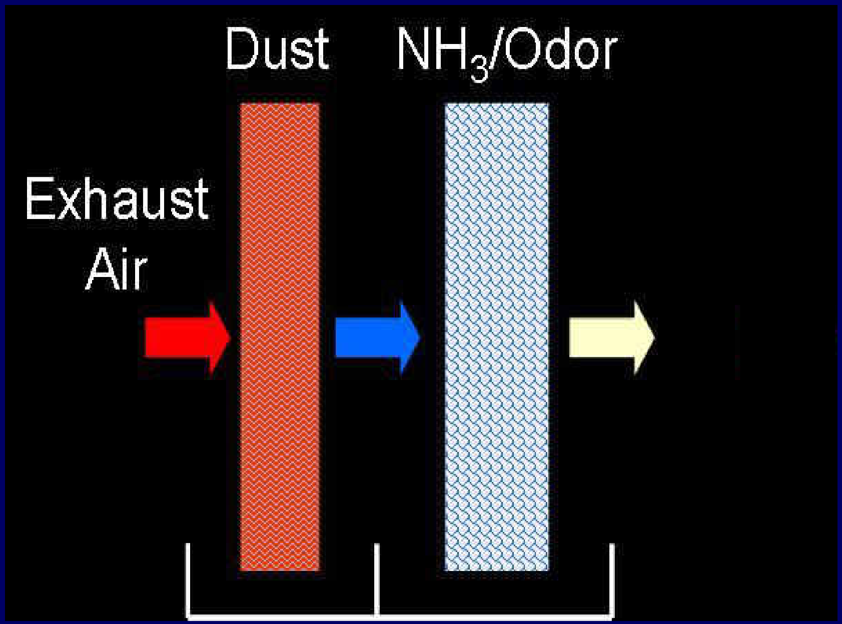
Acid and Multi-Stage Scrubbers

- Commercial (single or multi-stage) units are being adopted to control NH_3 and odor for animal housing in Germany and Holland.
- As of January 1, 2008, 10% of swine barns & 0.4% poultry barns in Holland used exhaust air scrubbers for NH_3 removal.
- Research are being conducted in US on acid scrubbers for poultry houses (AR, OH).

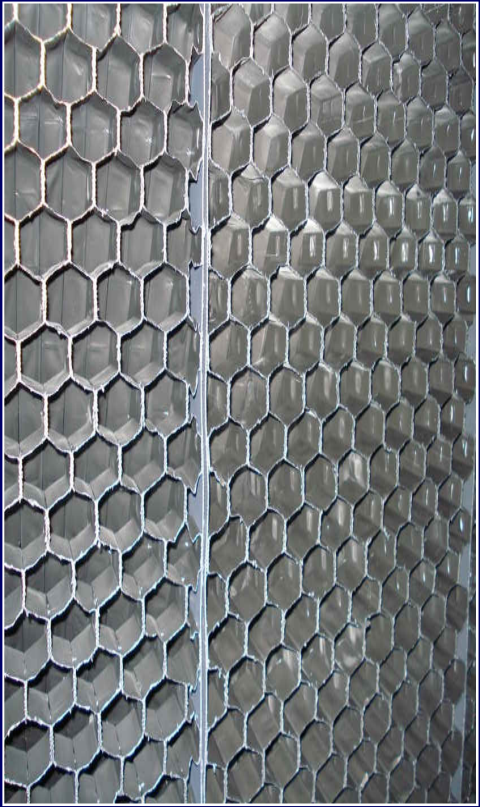
Acid Scrubbers

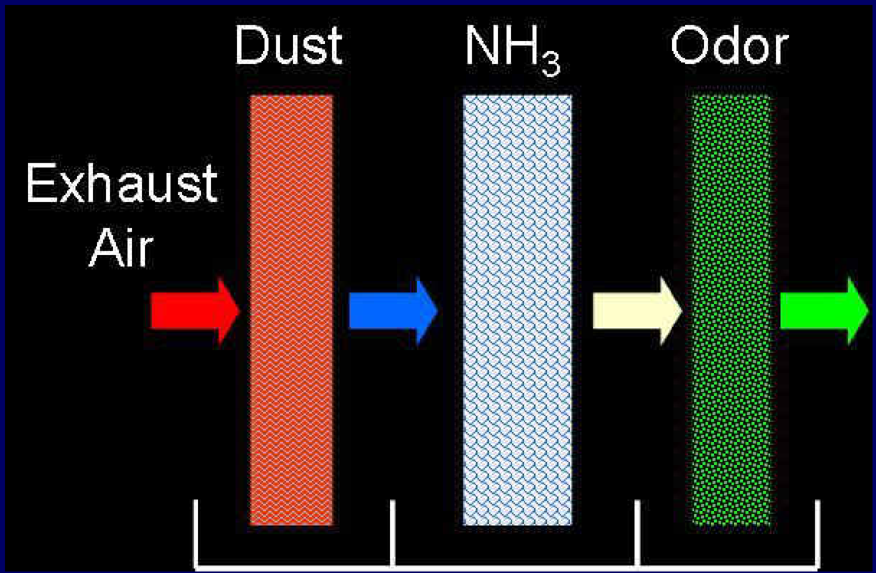
- A weak sulfuric acid solution (pH of 2 - 4) is re-circulated over the surface area of the scrubber as exhaust air passes over it.
- Gaseous NH_3 reacts with the acid to form ammonium (NH_4) salt and is retained in the solution. When solution pH >4, it is replaced and the spent solution is stored until re-processing or use as a nitrogen fertilizer.

Scrubber Design



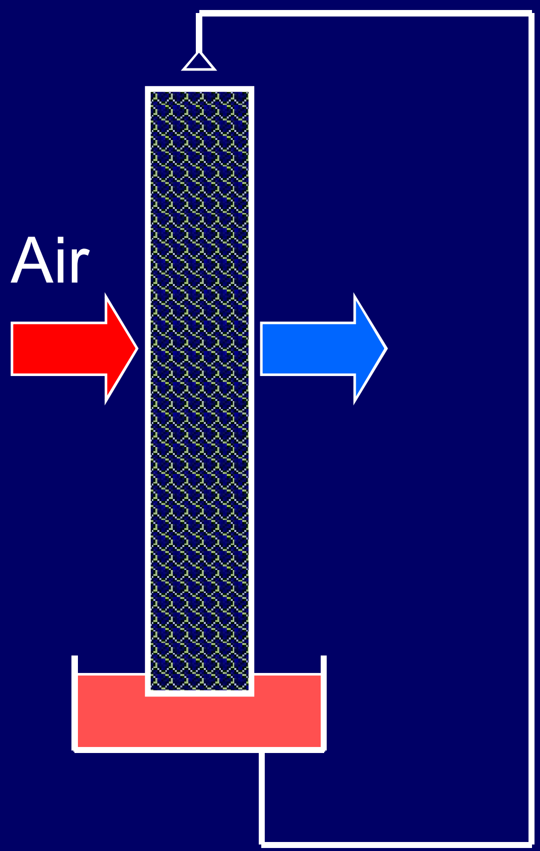
2-stage scrubber



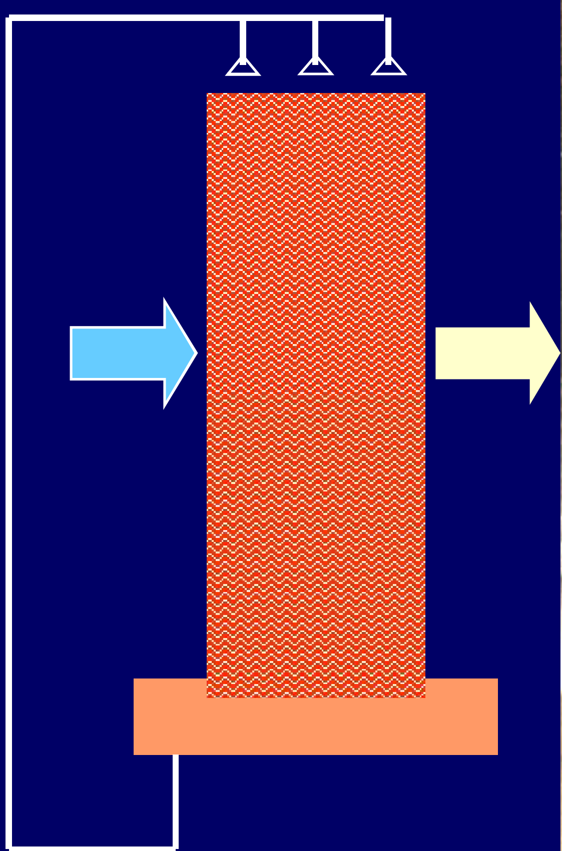


3-stage scrubber

Dust Removal

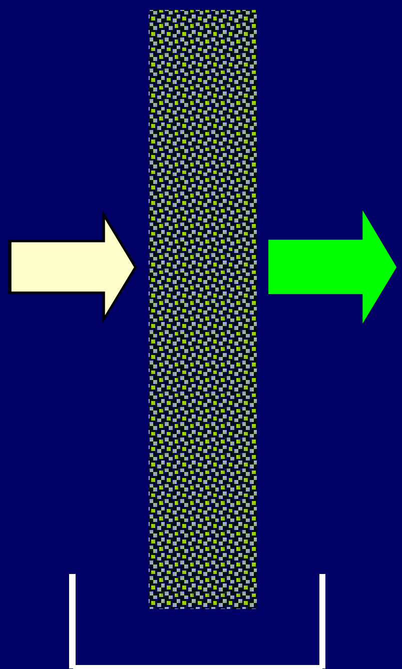


Ammonia Removal



- Sulfuric acid solution pH 2
- Recirculation
- Discharge when pH > 4

Odor Removal



A G-F pig barn in Germany

- Bacterial digestion with biofilter
  - Volatile fatty acids
  - Sulfuric compounds

Acid Scrubber

Farm Installation of Air Scrubber (G-F Pig House in NL)

Acid Scrubber

The system requires on-farm storage of both fresh and spent acid solutions.

Farm Installation of Air Scrubber (Broiler House in NL)

Measured removal efficiencies for NH_3, odor, and PM by farm-scale multi-pollutant scrubbers in the Netherlands

Ammonia	Odor	PM_{10}	$PM_{2.5}$
63 – 98% Avg: 81% (n = 7)	0 – 83% Avg: 40% (n = 8)	41 – 46% Avg: 43% (n = 2)	23 – 61% Avg: 42% (n = 2)

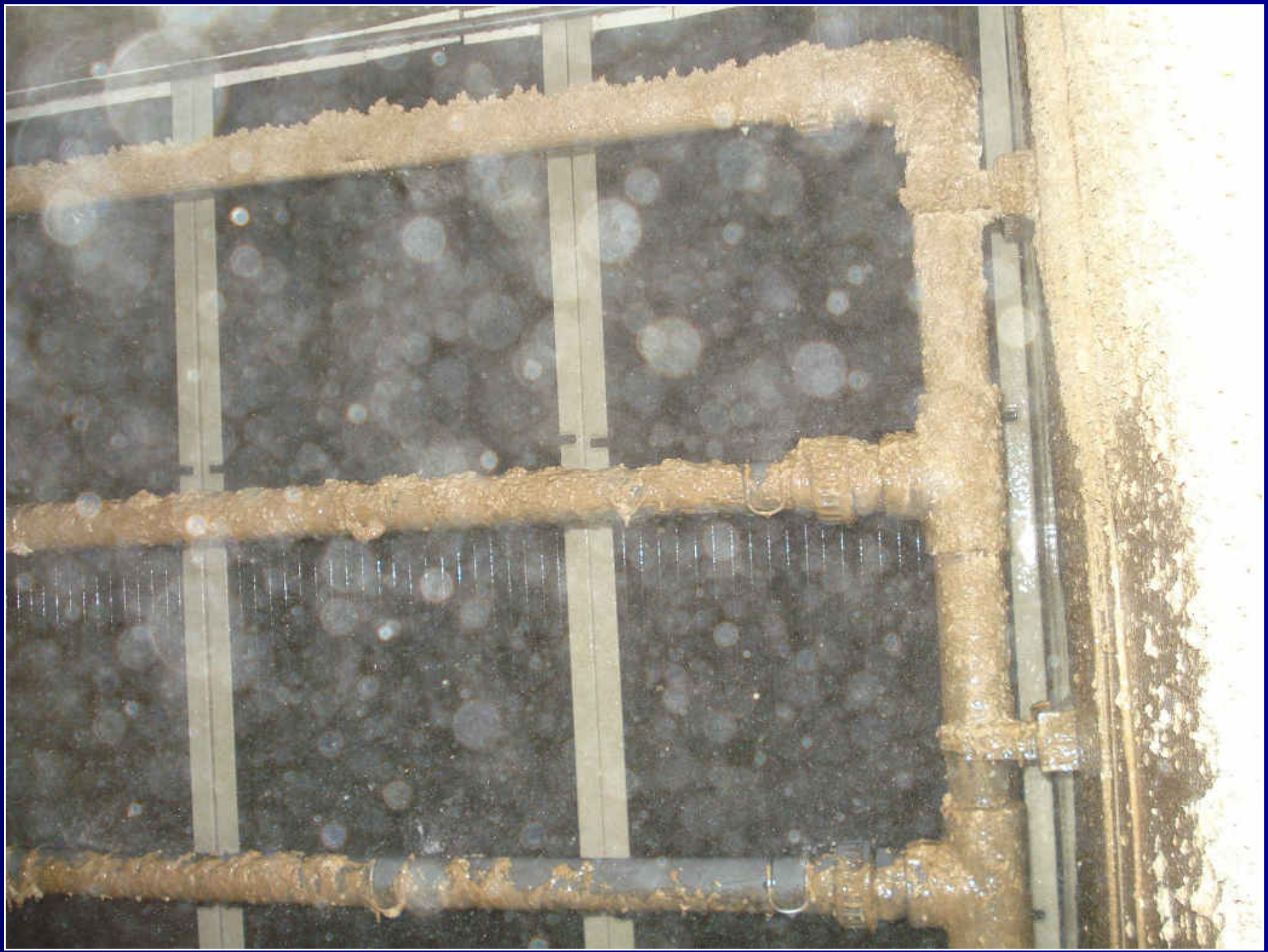
Source : Melse et al. (2008)

Investment and Operational Costs of Scrubbers for Newly Built Facilities in $ per Pig Space

Cost Type	Acid Scrubber	Multi-stage Scrubber
Capital	$47	$72
Operational (per year)	$15	$19

Source : Melse et al. (2008)

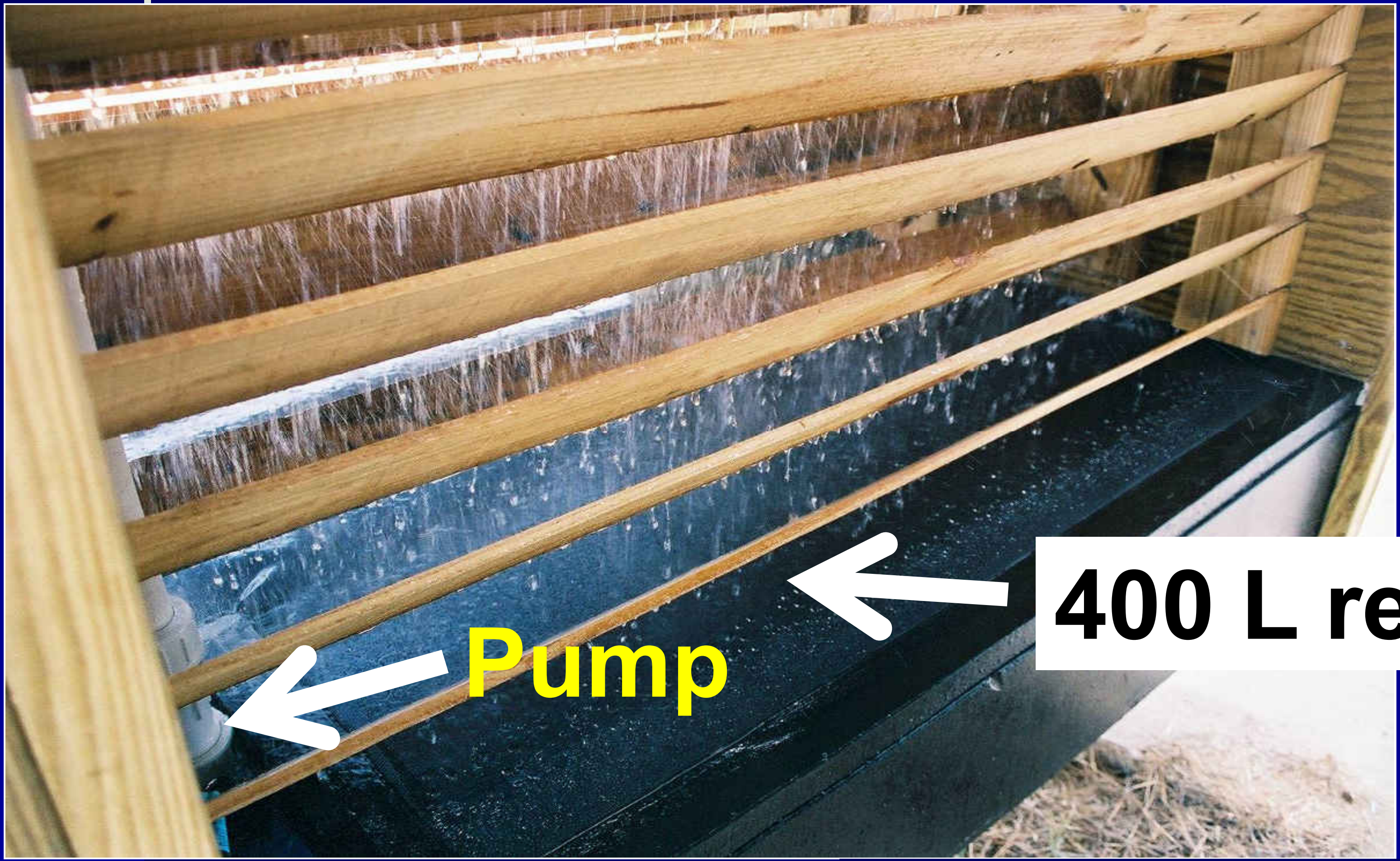
Challenge of Dust to Scrubbers



Wet scrubber for controlling NH_3 and dust developed by ARS (P.A. Moore)

Slide credit: P.A. Moore – USDA ARS

Moore is evaluating the efficacy of this system for scrubbing NH_3 from the broiler house exhaust air. Moore reports the construction cost of this system to be ~ $1000.



100 L alum + 220 L water

Slide credit: P.A. Moore – USDA ARS

SUMMARY

- Nutritionally balanced hen diets with lower crude protein helps reducing ammonia (NH_3) emissions w/o adverse impact on hen production performance.
- EcoCal (7%) and DDGS (10%) diets have been shown to reduce NH_3 emissions from high-rise layer houses by 39% and 14%, respectively, based on a 2-year field study.

SUMMARY

- Frequent removal of manure from animal houses improve IAQ and significantly reduce house-level ammonia (NH_3) emissions.
- Ammonia emission rate increases with hen manure accumulation time (1 – 7 days).
- Reducing manure storage surface area reduces NH_3 emissions; higher manure MC or temperature lead to higher NH_3 emission.

Summary

- Litter additives are commonly used in broiler and turkey productions systems to reduce in-house NH_3 levels.
- Exhaust air scrubbers for NH_3 and odor control are being applied to swine and some poultry systems in Europe, but have not been adopted on a commercial scale in the US.

Hongwei Xin, Professor

Iowa State University

hxin@iastate.edu

http://www.ans.iastate.edu/EIC