

Mitigation of Poultry Ammonia Emissions

Part II: Mitigation through Manure Additives & Exhaust Air Treatment

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Sources of Emission 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)

Post-excretion Mitigation





Indoor Treatment to Reduce NH₃ Generation

Manure/Litter Additives

- Natural zeolite $[(Na_xK_x)(Al_6Si_{60})O_{360} \cdot 24H_2O]$
 - 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


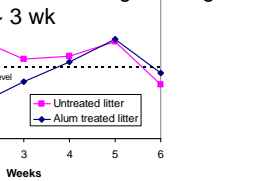
Reduction of Ammonia Emission from Stored Hen Manure from Topical Application of Additives

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 ft² 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

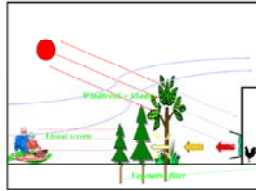
- Dispersive Systems with some treatment
 - Vegetative Buffers
 - Windbreak Walls
 - Biomass Walls & Bio Curtains

- Exhaust Air Treatment Systems
 - Biofilters
 - Single Stage Biological Scrubbers
 - Single Stage Acid Scrubbers
 - Multi-Stage, Multi-pollutant Scrubbers

Vegetative Environmental Buffer

Date reported from a broiler house in DE:

- PM reduction: $49 \pm 27\%$ (33 d)
- NH_3 reduction: $46 \pm 31\%$ (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)

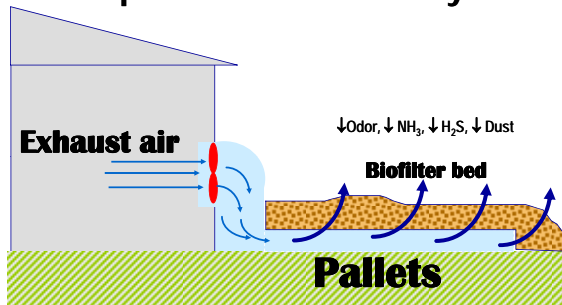
Bio-filters and Scrubbers

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

Biofilters

- Have been used for odor control on swine houses in Germany for 20 + years (Oldenburg Biofilters)
- Have been researched and demonstrated in the US for a 10 + years (Hoff, Jacobson, Nicolai and others)

Open-faced Biofilter System





Acid and Multi-Stage Scrubbers

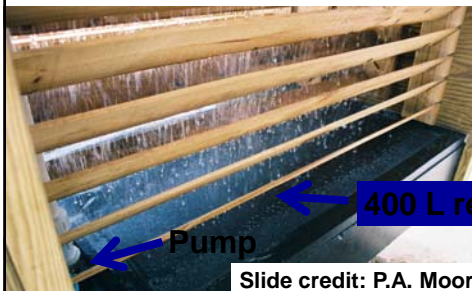
- Some research currently being conducted in US on acid scrubbers for poultry houses (Moore).
- Commercial units are being rapidly adopted for ammonia control on swine systems in the Netherlands and Germany.
- Some commercial multi-stage scrubbers are in use on Dutch poultry systems. Must include a particulate removal first stage.

Wet scrubber for controlling ammonia and dust developed by ARS (Philip Moore)



Slide credit: P.A. Moore – USDA ARS

Moore is currently evaluating the efficacy of this system for scrubbing ammonia from the air exhausted from broiler houses. Moore reports the construction cost of this system to be ~ \$1000.



**100 L
alum +
220 L
water**

Slide credit: P.A. Moore – USDA ARS

Acid Scrubbers

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

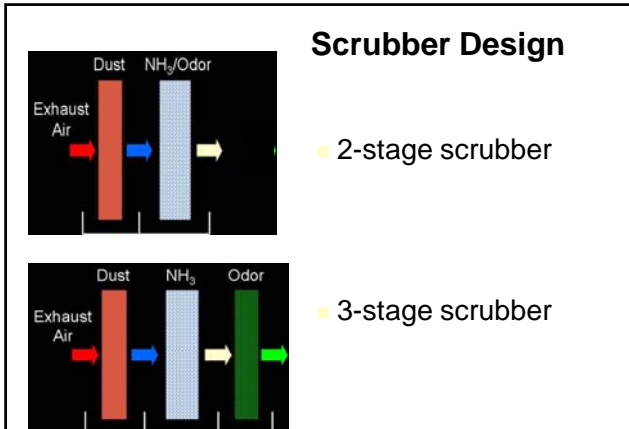
Acid & Multi-Stage Scrubber use in Europe

- Exhaust air scrubbers are currently being used on a commercial scale on swine production housing in Germany and for swine and poultry in the Netherlands.
- 10% of Dutch swine systems used an exhaust air scrubber for NH₃ removal as of January 1, 2008.

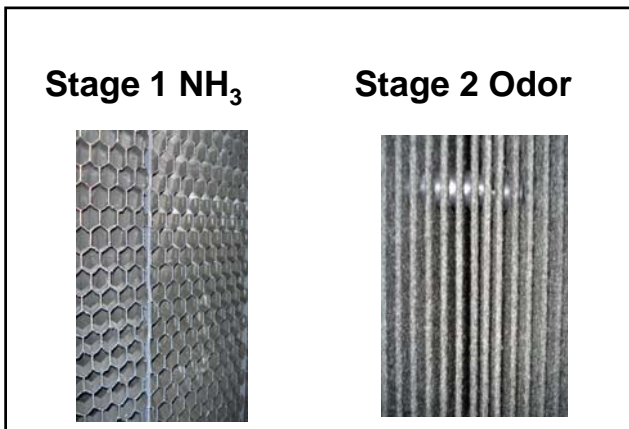
Animal Housing Ammonia Scrubber Installations in the Netherlands

Systems Installed as of Jan. 1, 2008	Treatment Capacity (CFM)	# of farms
Acid scrubbers	39 million	790
Biotrickling filters	8 million	90
Total:	47 million	880
Pig	45 million (10%)	850
Poultry	2 million (0.4%)	30
Total:	47 million	880

Source : Melse, et al, 2008

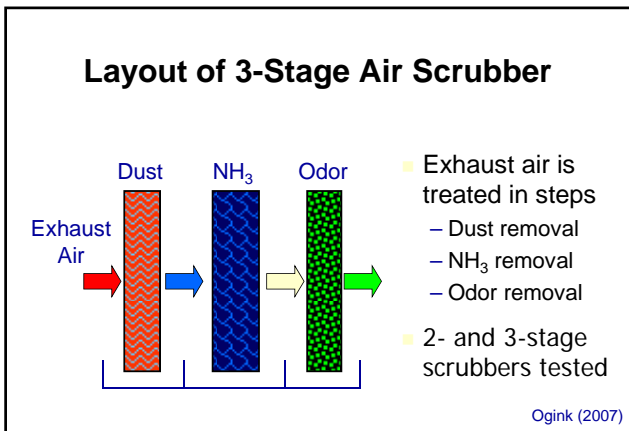














Dust Removal



The diagram shows a vertical air filter unit with a red arrow labeled 'Air' entering from the left and a blue arrow exiting to the right. Below the filter is a red collection tray. To the right are two photographs: the first shows a close-up of a dark, rectangular air filter unit in a room; the second shows a long, narrow aisle in a barn with a yellow floor and a white wall, illustrating the application of dust removal.

Ammonia Removal




The diagram shows a vertical air filter unit with a blue arrow entering from the left and a yellow arrow exiting to the right. Below the filter is an orange collection tray. To the right are two photographs: the first shows a close-up of a red, textured air filter unit in a room; the second shows a long, narrow aisle in a barn with a white floor and a white wall, illustrating the application of ammonia removal.

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

Odor Removal

A G-F pig barn in Germany



The diagram shows a vertical air filter unit with a yellow arrow entering from the left and a green arrow exiting to the right. Below the filter is a blue collection tray. To the right is a photograph of a long, narrow aisle in a pig barn with a white floor and a white wall, illustrating the application of odor removal.

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

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



Farm Installation of Air Scrubber (Broiler House in NL)



Measured removal efficiencies for ammonia, odor, and particulate matter (PM) by farm-scale multi-pollutant scrubbers in the Netherlands

Ammonia	Odor	PM10	PM2.5
63 - 98%	0 - 83% [a]	41 - 46%	23 - 61%
avg: 83%	avg: 40%	avg: 43%	avg: 42%
n = 7	n = 8	n = 2	n = 2

Source : Melse, et al, 2008

Investment and operational cost of scrubbers for newly built production facilities in \$ / pig space

Cost Type	Acid scrubber	Multi-Stage scrubber
Capital costs	\$47	\$72
Total operational costs (year ⁻¹)	\$15	\$19

Source : Melse, et al, 2008

Summary

- Litter additives are commonly used in broiler and turkey productions systems to reduce in-house ammonia levels
- Exhaust air scrubbers for NH₃ and odor are being used on swine and some poultry systems in Europe, but have not been adopted on a commercial scale in the US .
