Litter Management for Bird Health

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Litter re-use has become common
“as the litter goes, so goes the flock”
Litter Management

• How litter is managed before, during, and after each flock is a key factor for successful poultry growers
• Litter management starts with the previous flock
• Litter management between flocks is critical
• ABF management strategies
Potential Problems with Litter Re-use

- Higher ammonia during brooding
- Litter moisture challenges
- Increased energy use to maintain air quality
- Pathogen carry over
  - Breaking with same disease conditions flock after flock
Ammonia

- A major issue with re-utilization of litter is the generation of ammonia.
- High ammonia levels in poultry houses can result in poor bird performance and health and a loss of profits to the grower and integrator.
- Reducing brooding stress is crucial for achieving a low-cost per-pound live weight.
Built-up Litter Profile

Ammonia

Ammonium

Nitrite

Nitrate

Aerobic

Anaerobic
Adverse Effects of Ammonia

• Damaged respiratory system & increased susceptibility to disease
  – As low as 10 ppm
Damaged Cilia
- Reduced ability to remove contaminants
- Increased susceptibility to airborne pathogens
Adverse Effects of Ammonia

• Poor body weights, feed efficiency & condemnation rates
  – Levels that exceed 25 ppm
Ammonia Concentration and Broiler Performance

Body Weight

- 0 ppm: 4.25
- 25 ppm: 4.20
- 50 ppm: 4.04

Feed Conversion

- 0 ppm: 1.90
- 25 ppm: 1.94
- 50 ppm: 1.98

Condemnations

- 0 ppm: 0.6
- 25 ppm: 5.2
- 50 ppm: 5.3

Quarles and Caveny, 1979
Ammonia Volatilization

• Ammonia volatilization hinges on:
  – Temperature
  – Air turbulence
  – Litter pH
  – Litter moisture

• Which is the most important?
Uric Acid Aerobic Degradation

Uric Acid $\xrightarrow{\text{Uricase}}$ Allantoin $\xrightarrow{\text{Allantoinase}}$ Allantoic Acid $\xrightarrow{\text{Allantoate Amidohydrolase}}$ Uriedoglycolate $\xrightarrow{\text{Ureidoglycolase}}$ Glyoxylate + Urea $\xrightarrow{\text{Urease}}$ $2\text{NH}_3 + \text{CO}_2$

$\text{CO}_2$ $\xleftarrow{\text{Uridoglycolase}}$ $\text{CO}_2 + 2\text{NH}_3$

Bongaerts and Vogels, 1976
Bachrach, 1957
Litter Moisture and Welfare

Dunlop, et al., 2015, 2016

• ‘Wet litter’ has been implicated as a primary cause of contact dermatitis in poultry (Shepherd and Fairchild, 2010)
• ‘Wet litter’ negatively affects feed conversion ratio and carcass yields (de Jong et al., 2014)
• ‘Wet litter’ can be caused by a combination of diet/nutrition factors (Collett, 2012); shed design, ventilation management and environmental factors (Hermans et al., 2006); and/or flock infections with organisms such as Clostridium perfringens, the causative agent of necrotic enteritis (M'Sadeq et al., 2015).
• The amount of water in litter has been found to affect microbial activity (Bessei, 2006; Eriksson De Rezende et al., 2001; Himathongkham et al., 1999; Wadud et al., 2012),
Litter Moisture

Dunlop, et al., 2015, 2016

- Water added to litter from excreta and spillage can be as much as 3.2 L/m²/day (0.85 gal; ~2500 gal/house)
- Water holding capacity of litter increases during grow-out
- Water evaporation rate depends on litter moisture content and air speed
Moisture Control

- Regular check of water systems to prevent/repair leaks
- Adjust drinker height and water pressure appropriately as birds grow to avoid excessive spillage into the litter.
Moisture Control

- Maintain uniform bird density
  - Cull birds
  - Timely movement
  - Migration fences
Moisture Control

• Use circulation fans continuously during and between flocks
  – Moisture from the bedding material
  – Bird moisture
• Storm water diversion from housing and pad
• Floor moisture removal - may be more important than we think
• Sufficient bedding depth
  – Minimum depth of 3 inches
Bedding Depth

- Depth variability across the house can be a problem
- Can’t afford to ventilate to compensate for the lack of “sponge” depth
- Evaporative ‘drying’ capacity may be more important than absorption
Moisture and Paw Quality

- Litter quality
- Litter type
- Litter depth

3-point visual ranking scale used to score footpad lesions in the production house:

- Score of 0 for no scab or lesion present.
- Score of 1 for a mild lesion (lesion ≤ 7.5mm, dermis only, on one or both feet).
- Score of 2 for a severe lesion (scab or open sore lesion > 7.5 mm, on one or both feet).

Similarity to processing plant grade:
- "A" Grade = Score of 0
- "B" Grade = Score of 1
- "C" Grade or Condemn = Score of 2

Source: Shepherd and Fairchild, 2010
Litter Re-use Requires...

A. Management between flocks
B. Ammonia control...through use of litter treatments
Traditional Reconditioning: Decake or Till
Other Options
In-House Windrowing
Justification for Litter Windrowing

• Prolonged litter reuse
• Persistent disease challenge
• ABF management strategies
Windrowing Litter

• What it isn’t:
  – True composting
  – Litter sterilization

• What it is:
  – Partial heat treatment
  – Pasteurization (partial sterilization)
Windrowing Economics

- Virginia DEQ study (Flory et al., 2008)
  - 2 house farm with history of necrotic enteritis

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control (decaked)</th>
<th>Windrowed</th>
<th>Difference</th>
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</thead>
<tbody>
<tr>
<td>Ave. weight</td>
<td>4.26</td>
<td>4.43</td>
<td>+ 0.17</td>
</tr>
<tr>
<td>Total weight</td>
<td>145,945</td>
<td>154,498</td>
<td>+ 8,553</td>
</tr>
<tr>
<td>Feed conversion</td>
<td>1.84</td>
<td>1.77</td>
<td>- 0.07</td>
</tr>
<tr>
<td>Livability</td>
<td>92.56%</td>
<td>95.00%</td>
<td>+ 2.44%</td>
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<tr>
<td>% Condemned</td>
<td>0.21</td>
<td>0.14</td>
<td>- 0.07%</td>
</tr>
<tr>
<td>Grower pay</td>
<td></td>
<td></td>
<td>+ $1,998</td>
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</table>
VA-DE In-house Windrowing Study

• Achieved +135°F temperatures
• 99.99% reduction in E.coli and Salmonella
• +8,500 lbs more chicken
• Additional costs for windrowing
  – $700 propane
  – $300 custom windrowing ($225 for traditional crusting)
  – $100 leveling windrow
AU In-house Windrowing Study

• Microbial testing
  – Aerobic and anaerobic bacterial counts lower in windrowed vs. un-windrowed litter
    • Clostridium perfringens reduction >99%
    • ILTV completely eliminated in litter after 5 days
      – However…house again positive with subsequent flock
        » House dust?
Getting Started

• Start windrowing program after a total cleanout, or if beginning with built-up litter, start during moderate or warm weather.
  – Gives you time of get use to the process without the added challenges of cold weather brooding
• Minimum 12-14 days needed for windrowing program
• Ideal litter depth 4-6 inches
• Form windrows within 2 days after catch
• Ideal windrow height 36-48 inches
Working the Litter

- Three to four days after formation, windrows should be turned.
- Best to turn windrows at least once and several times if possible before leveling.
- The entire windrow should be shifted during the turning process to expose the litter mass to high temperatures and the floor to the drying effects of the atmosphere.
Example of windrow temperatures following each turn event
Windrow Temperatures

~120 F
~140 F
~120 F
Working the Litter

- From a pathogen reduction standpoint, the goal is to reach at least 130 °F and sustain for a minimum of 3 to 4 days.
- Exposing all the litter to high temperature is needed to reduce or eliminate pathogens.
- Monitor windrow internal temperatures until confident with process.
Working the Litter

• For farms with a significant disease challenge, best to remove all litter from the sidewalls and corners and incorporate into the windrow.

• A building wash down prior to windrowing will help incorporate any pathogen-laden dust into the pile. Allow sufficient time to dry the litter if this step is completed.

• May take 2 consecutive windrowing events (flocks) to break some diseases (ie. Dermatitis) and reduce re-occurrence.
Completing the Process

• Ideal time to get maximum beetle kill would be to apply insecticide to windrows within 6 hours after pile formation.

• Ventilate during the entire process. Closing up houses following windrowing to retain heat will have little impact on windrow temperatures. Depending on ambient weather conditions, minimum vent fan(s) set on timer or run a tunnel fan(s) set on temperature. Circulation fans should be kept on to help move the air and dry down the litter.
Completing the Process

- Leveling the windrows *at least 4 days* prior to chick placement is recommended.
- It is *critical* that adequate time be devoted to “cooling down” and drying out the litter.
Completing the Process

• Increased application of a litter amendment (25% +) may be required to suppress ammonia, particularly in cool weather.

• Higher ventilation rates may also be needed during brooding to control ammonia. Ammonia control tends to be more manageable after a few flocks once a windrowing program is initiated.
Time Commitment

• Forming the windrow 60 min.
• Each turn 45 min.
• Leveling 60 min.
• Washing Equipment 30-60 min.

3-4 hours per house
Windrowing Economics

- Grower perspective
  - Farms with disease challenge or poor performance can potentially see very positive results
  - May be difficult for high performing farms to see benefits (even if benefits exist)
    - “More work and expense for little or no return”
Factors Affecting Windrowing Economics

• Farm disease/pathogen history
• Equipment/equipment operator
• Litter condition/moisture
• Season/weather
• Length of downtime between flocks
• Cost of not windrowing
Key Points

• Good litter management tool
  – Not a silver bullet
  – Not an ammonia control tool

• May lead to ammonia problems under certain circumstances
Alternative Strategies to Save Time and/or Money

- Windrow every other flock
- Clean out brood end, windrow back end
- Custom/contract windrowing ($300-500 per house)
What windrowing doesn’t do

• Decrease litter volume – not enough time spent composting
  – Will need to remove some litter eventually before proceeding with a subsequent flock.

• Will not significantly change (increase) the fertilizer value (N content) of litter at time of cleanout.
Windrowing…
may not be for everyone!

• Average or below average growers
  ~80% will show improvement ($50-120 per 1000 birds)

• Top growers
  – May not see any sustained improvement
    • May see boost at sale if you are one of the first in a complex to windrow
  – May smooth out a few bumps in the road
    • Prevent the disease outbreak that catches others
Windrowing Summary

• Challenges
  – Time consuming
  – Grower ability
  – Equipment
  – “Dirty” work

• Outcomes
  – Pathogen reduction
  – Improved bird performance
Lots of windrowing equipment now available
Windrow Composting of Litter to Control Disease-Causing Pathogens

By Jim McDonald, Sara Simpson, Jim Donald, and Jass Campbell, Auburn University

Reusing litter after a disease outbreak is something that you want to do. However, new strains and its general lack of availability, as well as the cost of equipment and labor, are challenges. One way to tackle application of litter is to make use of the contaminated litter that is the pathogen-inhabited chickens. In fact, pathogenic microorganisms that caused the disease in the first place are still present. So the question becomes: how to clean up the litter for reuse?

There are several ways to do this. The first and easiest way is to allow the litter to sit for a couple of months. Of course, if the problem with this is that even the corn of having a house or a group of hens for that long is very high. Another use of litter amendments is to add a commercially sold litter amendment work by which will kill many microorganisms. An important fact that is often overlooked is that this should be added into the litter in order to be effective. It is not simply the addition of the amendment, which means that the litter might not be effective. If not treated, the amendment spread throughout the litter, making the litter on the top of the litter ineffective. To use a whole amendment to the litter is a way to make the litter more effective.

The second method is in-house window composting. This method is a reliable and cost-effective way to greatly reduce pathogens. If I were to use the term "pasteurization" instead of calling the process composting pasteurization, simply, pasteurizing the process is pasteurization. This method is pasteurization, which uses heating to kill microbial disease organisms. The pasteurization accomplished on this method is typically not as thorough as traditional composting in killing disease organisms. The difference between the two is that in-house composting is generally only performed for 10-15 days, while traditional composting is performed for several weeks or even months. However, research studies conducted at Auburn University have shown that it is possible to accomplish pasteurization in a shorter period of time.

Window composting has the litter enough to accomplish pasteurization, killing almost all disease organisms. After the litter has been spread out and allowed to cool for a day, you are left with dry litter that is ready for the next flock.

Many of the water bodies that are impaired by bacteria throughout the state are located in the poultry producing regions of Texas. Poultry production has expanded significantly in recent years, leading to increased nutrient pollution. An estimated 500 new poultry houses have been built in this area, producing approximately 60 million MDLs annually. If improperly managed, litter (the combination of bedding material and manure) removed from the facility and applied to surrounding land represents a threat to water quality through bacterial and nutrient runoff from these fields.

Cost-effective best management practices (BMPs) are needed to reduce the environmental impacts from new and existing facilities. One such BMP is in-house window composting (WVC) of poultry litter. WVC is a management strategy used by commercial poultry producers to reduce pathogenic microorganisms in litter and improve the overall quality between successive flocks reared on the same litter.

The Environmental Effects of In-House Window Composting of Poultry Litter project is demonstrating the environmental effects of treated poultry litter. It is anticipated that the WVC procedure will eliminate most E. coli in the litter, thus reducing its contribution to bacterial contamination of water resources. Successful implementation of the WVC procedure could reduce the cost of treatment and improve the quality of poultry litter before it is removed from the house.

Objectives:
- Analyze the impact of WVC on bacteria, microorganisms, and nutrients in litter
- Analyze the economics of WVC versus current methods
- Evaluate the environmental impacts of WVC
- Disseminate information and provide training for BMP demonstrations and evaluations to growers and integrators throughout the poultry producing areas of Texas

Windrowing litter is a cost-effective best management practice that reduces the amount of microorganisms in poultry litter before it is removed from poultry houses. This project is demonstrating environmental effects and benefits of treating poultry litter using in-house windrow composting.
Litter Re-use Requires...

A. Management attention between flocks

B. Ammonia control...through use of litter treatments
Justification for Litter Treatment Use

- Prolonged litter reuse
- Persistent disease challenge
- Increased bird density
- Marginal management and housing*
- ABF management strategies
Using Amendments

• Litter has high buffering capacity.
  – pH correction is only temporary
  – More NH₃ potential than can economically amend (chemical imbalance)
• Appropriate house prep will extend product life.
  – De-cake
  – Preheat
  – Moisture content
• Tilling in product will shorten effectiveness
Treatment Types

• Acidifiers
• Biological Inoculants
• Adsorbents, Neutralizers, Masking Agents
Ammonia Suppression through Acidification

Ammonia (\(\text{NH}_3\)) – volatile N
Ammonium (\(\text{NH}_4\)) – nonvolatile N

\[ \text{NH}_3 + \text{Acid} \rightarrow \text{NH}_4\text{Salt} \]
Built-up Litter Profile

Ammonia

Ammonium

Nitrite

Nitrate

Aerobic

Anaerobic
Temporary Acid Effect

Acid Barrier

Ammonia

Ammonium

Nitrite

Nitrate

Aerobic

Anaerobic
Acidifiers

- Create acidic litter conditions (pH < 7), resulting in more ammoniacal nitrogen temporarily retained as ammonium rather than ammonia.
- Acidity creates unfavorable conditions for bacteria and enzymes that contribute to ammonia formation, resulting in reduced ammonia production.
Acidifiers - Safety

• Most of these products carry OSHA warnings ranging from mild irritant to the highly corrosive.
Acids - Safety

• Products have FDA GRAS Status (Generally Regarded As Safe)
• Not for use as a direct food or drug additive.

UGA Feeding Study:
– Surface appl replicates
– Force fed worst-case scenario

➤ No significant difference in BW for typical appl rates
➤ No difference in mortality
➤ Specific lesions with force feeding
Acids - Efficacy

- Dry litter can delay activation of some acidifiers.
- Tilling treatment into the litter will reduce product longevity.
- Uniform application across the house is needed.
- More is not always better.
Acids - Efficacy

- Litter has high buffering capacity – pH correction short-lived effectiveness.
- Appropriate house prep will extend product life.
Application Strategies

• Uniform application across the house is important to prevent corner and sidewall accumulation.
  – Treating the litter, not the birds.
• Timely maintenance and monitoring watering system.
Preparing the House

- Remove/process caked material between flocks.
  - Caked litter is high in moisture and nitrogen
- Ventilate during down time
- Before applying treatment, run fans to remove ammonia.
- Ventilate during preheating
- Use circulation fans
- Maintain sufficient bedding depth
Application Scenarios

• Whole house
• Brood end only
• Brood end high rate, back end low rate
• Liquid application
• Mixed products application – acidified salts
• Higher rate with windrowing, tilling
• ABF mgt - Secondary application 12-14 day of age
Application Points

• Acidifiers activate and behave differently.
  – Hygroscopic activators (readily absorb moisture from atmosphere, forming a liquid solution)
  – Contact activators
  – Liquid products

• Application lead time before chick placement is the widest variable between products.

• Zone of influence
  – Uniform coverage is imperative
  – Temperature influences chemical reactions
Application Points

• Tendency to ventilate less than is necessary.
  – Reduced fan run time will increase house moisture levels.
    • Sweat house
    • Reduce litter treatment efficacy

• To better achieve desired results, **key is to follow manufacturer recommendations for house preparation and product application.**
Broiler Litter Nutrient Value

% broiler litter average

Flocks

Total Nitrogen

P2O5
Acid Treatment Influence on Nutrient Value
Litter Treatment Summary

- Litter treatments that significantly reduce litter pH result in the greatest reduction in ammonia volatilization.
- Acidifiers inhibit bacterial and enzymatic activities involved in the formation of ammonia.
- Follow manufacturer recommendations for litter treatment application.
Litter Management Benefits

- Reduce ammonia production
- Increase litter amendment effectiveness
- Increase energy efficiency
- Promote appropriate litter moisture (20-25%)
- Maintain optimal bird health