Conclusions from a Literature Review on Poultry Stockpiling

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VA Poultry Production is increasing
2000 Adoption of the first AFO Permit

15% increase in N Loads, largely due to growth since initial VPA-AFO Adoption
• Point # 1: The scientific literature on stockpile nutrient leaching and runoff is variable, with some clear instances of leaching/runoff and other instances of minimal loss.

• Point #2: The impact of covering is also variable, although in many cases, covering provides a nitrogen and phosphorus benefit through various mechanisms. There were no clear/significant instances where covering increases overall nutrient loss.

• Point #3: Ammonia Emissions from litter piles are substantial and potentially a more important nutrient considerations than leaching. Literature suggests covering piles immediately can substantially reduce ammonia emissions, although the long term fate (i.e. after spreading) of ammonia depend on various management factors. Litter additives are recommended to manage ammonia and have potential benefits for bird health.
• Point # 1: The scientific literature on stockpile nutrient leaching and runoff is variable and at times conflicting, with some clear instances of leaching/runoff and other instances of minimal loss.
Example #1

Binford et al 2008

Annual estimates of nitrogen loss (Runoff/Leachate): ~17 lbs inorganic DIN per 100 tons of poultry litter
**Example # 2**

Costello et al. (2001) reported that litter properties changed very little in a tarp-covered stockpile, whereas N and C concentrations decreased in an uncovered stockpile over a 13-month study in Arkansas. The **uncovered stockpile had surface runoff concentrations of suspended solids and nutrients comparable to liquid animal waste**. Unlike Shah et al. (2009), who reported considerable leaching of pollutants into the soil (loamy sand), Costello et al. (2001) **reported very little leaching**, which may also be due to differences in soil properties (not reported).
Example #3

• In a study in eastern North Carolina, soluble chemicals (N, P, C species) leached into the soil to a depth of at least 24 in. from uncovered turkey litter and cake stockpiled for 12 months (Shah et al., 2009). At the end of the study, ammonium (NH4) concentrations were 62 times higher in the 12- to 24-inch soil layer beneath the stockpile than in the same layer in the adjacent soil outside the stockpile footprint (Shah et al., 2009).

• Soil cores 12 to 24 in. beneath the stockpiles were dark because of dissolved organic C (DOC) leaching from the stockpiles and had a strong smell of ammonia. Leaching of DOC and soluble P from the stockpiles likely solubilized arsenic (As) in the soil, resulting in elevated soluble As levels beneath the stockpiles (down to 24 in.) compared to levels outside the stockpile footprint.
• **Example #4**

Zebrath et al. (1999) stockpiled solid turkey manure on coarse-textured soil in British Columbia, Canada, over six years from fall through winter. **Nutrient concentrations down to 12 ft were much higher beneath the stockpile than outside, with NH4 concentrations 120 times higher.** similar to the findings of Shah et al. (2009).
•Point #2: The impacts of covering on leaching/runoff are variable, although in many cases, covering provides substantive benefit. Nitrate loss tends to be higher in covered piles but Total Nitrogen loss is generally greater than or equal than uncovered piles.
Example #1

• Binford et al 2008 annual estimates of nitrogen loss:

“The results showed that on average the no-cover treatments lost 16 pounds of inorganic N, while the polyethylene cover was not significantly different and lost an average of 13 pounds of inorganic N.”
Example 2

During a 592-day study in Nova Scotia, Canada, Sullivan et al. (2009) reported that poultry litter stockpiles covered with tarps had about 20% lower runoff mass losses of total P, total Kjeldahl N (TKN), and total ammoniacal N (TAN) than uncovered stockpiles. Runoff loss of nitrate was slightly higher in the covered stockpiles. Leaching losses of the N species were 20 to 30% lower in the covered stockpiles. In both, covered and uncovered stockpiles losses were higher due to leaching than in runoff. (Sullivan et al., 2009).
• Example #3

• Zebrath et al. (1999) stockpiled solid turkey manure on coarse-textured soil in British Columbia, Canada, over six years from fall through winter. Nutrient concentrations down to 12 ft were much higher beneath the stockpile than outside, with NH4 concentrations 120 times higher, similar to the findings of Shah et al. (2009). Zebrath et al. (1999) reported that they did not find elevated nitrate levels beneath the stockpile—probably because high free ammonia in the soil solution was toxic to the nitrifying bacteria.

Table 3. Soil inorganic N to 210 cm depth below either a covered or uncovered field stockpile sampled at three times

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Covered NH₄⁺-N</th>
<th>Covered NO₃⁻-N</th>
<th>Covered Total</th>
<th>Uncovered NH₄⁺-N</th>
<th>Uncovered NO₃⁻-N</th>
<th>Uncovered Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before pile formation (27 October 1992)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–15</td>
<td>8</td>
<td>33</td>
<td>40</td>
<td>9</td>
<td>54</td>
<td>64</td>
</tr>
<tr>
<td>15–30</td>
<td>8</td>
<td>27</td>
<td>35</td>
<td>7</td>
<td>31</td>
<td>37</td>
</tr>
<tr>
<td>30–210</td>
<td>116</td>
<td>129</td>
<td>246</td>
<td>125</td>
<td>210</td>
<td>335</td>
</tr>
<tr>
<td>Total</td>
<td>132</td>
<td>189</td>
<td>321</td>
<td>141</td>
<td>295</td>
<td>436</td>
</tr>
<tr>
<td>After pile removal (11 May 1993)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–15</td>
<td>371</td>
<td>237</td>
<td>607</td>
<td>2123</td>
<td>8</td>
<td>2131</td>
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<tr>
<td>15–30</td>
<td>54</td>
<td>130</td>
<td>184</td>
<td>33</td>
<td>60</td>
<td>391</td>
</tr>
<tr>
<td>30–210</td>
<td>9</td>
<td>341</td>
<td>341</td>
<td>27</td>
<td>572</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>534</td>
<td>1132</td>
<td>1132</td>
<td>27</td>
<td>572</td>
<td></td>
</tr>
<tr>
<td>After leaving soil (15 December 1993)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–15</td>
<td>54</td>
<td>326</td>
<td>380</td>
<td>552</td>
<td>252</td>
<td>804</td>
</tr>
<tr>
<td>15–30</td>
<td>9</td>
<td>147</td>
<td>156</td>
<td>257</td>
<td>176</td>
<td>433</td>
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<tr>
<td>30–210</td>
<td>21</td>
<td>312</td>
<td>334</td>
<td>578</td>
<td>772</td>
<td>1350</td>
</tr>
<tr>
<td>Total</td>
<td>84</td>
<td>785</td>
<td>870</td>
<td>1386</td>
<td>1201</td>
<td>2587</td>
</tr>
</tbody>
</table>

“The results highlight the high potential for nutrient loss from uncovered fall and winter field storage of poultry manure”

N Leaches from piles, and this is 2 folds higher in uncovered piles.
Example # 4: Conclusions from North Carolina Agricultural extension Literature Review:

• 1. When allowed by regulations and if the quantity of waste to be stored is not excessive (say, hundreds of tons), enveloping a poultry waste stockpile will be economically and environmentally acceptable. If the waste is not excessively wet, if the site does not pond, and if it is protected from run-on, then covering the stockpile may be adequate.

• 2. Between short-term stockpiling events at the same site on soil, covering the stockpile footprint will reduce leaching or runoff losses (or both) of remnant stockpile pollutants.
Example # 5

Covering stacks reduced leachate total P losses by 25–100 times and total inorganic N losses by 25–770 times, such that leachate nutrient losses from covered stacks were similar to that in the controls with no manure stacking. Despite relatively small nutrient losses from litter stacks over the 2-year study, results point to substantial nutrient accumulation in soil after repeated stacking. Water-extractable P concentrations in upper 5-cm soils were similar between covered (120–240 mg kg⁻¹) and uncovered stacks (140–250 mg kg⁻¹), but soil nitrate-N concentrations were much higher under the covered stack (80–140 mg kg⁻¹) than the uncovered stack (<5 mg kg⁻¹).

“This study clearly points to benefits of covering litter stacks, but highlights long-term concerns with regard to soil nutrient accumulation.”

“New regulations should require that poultry litter stacks are relocated to a new area each year.”
• REVIEW OF POLLUTANT LOSSES FROM SOLID MANURES STORED IN TEMPORARY FIELD HEAPS Report for Defra Project: WT1006

• **Example #6**

- Covering poultry manure field heaps (with an impermeable sheet) was shown to be an effective method of decreasing leachate volumes and pollutant losses.

Fiona et al 2011
Point #3: Ammonia Losses from litter piles are substantial and potentially a more important nutrient consideration than leaching/runoff. Literature suggests covering piles immediately will substantially reduces ammonia emissions, although the long term fate of ammonia depends upon further management actions.
Example #1

• Ammonia loss per unit surface from the tarp treatment was 45% lower than the other treatments

Ammonia losses are substantive and higher in uncovered piles in the short term (Shah et al. 2013)
Example #2

The plastic-covered treatment lost less than 5%. The other treatments had losses of 12 to 16% (Sagoo et al., 2007).

Ammonia loss from the litter that had been stored under plastic was higher following land application than from litter that had been stored outside in a flat pile, indicating that most of the ammonia conserved during storage was lost during land application but incorporation of manure was critical to prevent ammonia losses. (Sagoo et al., 2007).

These measurements provide a good example of ‘N pollution swapping’ (i.e. an NH3 reduction strategy increasing NO3 leaching losses) and highlight the need to develop integrated manure management strategies that consider all N loss routes and forms.
• **Example #3,**

• Covering stockpiles with plastic ranked the most effective manure storage measure for reducing ammonia emissions from poultry litter with up to a 60% reduction expected.

<table>
<thead>
<tr>
<th>Abatement measure</th>
<th>NH₃ reduction, %**</th>
<th>Priority Points</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covering of poultry litter or solid manure with plastic covering or other synthetic sheeting</td>
<td>up to 60%</td>
<td>75</td>
<td>I</td>
</tr>
<tr>
<td>Usage of chemical or biological additives for slurry</td>
<td>up to 68%</td>
<td>75</td>
<td>I</td>
</tr>
<tr>
<td>Installation of light construction roofs over tall open tanks</td>
<td>up to 80%</td>
<td>70</td>
<td>III*</td>
</tr>
<tr>
<td>Replacement of lagoon slurry storages with covered tank or tall open tanks</td>
<td>30–60%</td>
<td>66</td>
<td>III*</td>
</tr>
<tr>
<td>Reduction of slurry storage surface (mirror surface) in new built storages</td>
<td>up to 60%</td>
<td>55</td>
<td>III*</td>
</tr>
<tr>
<td>Increase of litter stockpile height</td>
<td>up to 30%</td>
<td>55</td>
<td>II</td>
</tr>
</tbody>
</table>

* State support is needed to implement the measure; ** Bittman et al., 2014; UNECE, 2014; UNECE, 2015.
Example #4


“Practical applications to reduce NH3 emissions on the farm may include covering litter stockpiles to reduce wind flow over them or using intense ventilation between flocks coupled with an NH3 scrubber.”
• **Example # 5:**  
Sullivan et al. 2009  
• Covering the stockpile reduced ammonia by 92%, nitrous oxide by 73%, and methane emissions by 71% (Sullivan et al., 2009).
Based on Yao et al. 2011, we estimate that ammonia flux from a stockpile the size reported in Binford et al. would produce ammonia emissions (A) 2-3 orders of magnitude greater than N losses associated with leaching/runoff. We further estimate that nitrogen loads delivered to the bay as a result of these emissions would be an order of magnitude greater than N losses associated with leaching/runoff as reported by Binford. While there are many extraneous factors that may influence this comparison, the vast difference is startling and suggests the need to manage ammonia emissions.

Uncovered pile
Leachate/runoff: 0.12 g m^{-3} d^{-1}
(Binford et al 2009)

Uncovered pile
ammonia emissions: 21 g m^{-3} d^{-1} (Yao et al. 2011)

Estimated Delivery to the bay of ammonia emissions from uncovered stockpiles via Volkswagen settlement estimates (8.9%):
2.7 g m^{-3} d^{-1}

Ammonia losses have the potential to dominate nitrogen loads to the bay.
Ammonia is clearly a challenge that needs to be dealt with

Modeling and measurements of ammonia from poultry operations: Their emissions, transport, and deposition in the Chesapeake Bay

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**Highlights**
- Ammonia deposition to the Chesapeake Bay from Poultry CAFOs.
- AERMOD Modeling study.
- Sensitivity of ammonia deposition to deposition velocity.
- Measurements of atmospheric ammonia on Delmarva Peninsula.

**Graphical Abstract**

Ammonia is clearly a challenge that needs to be dealt with
Emission Estimates
• Total ammonia N emissions from 600+ AFOs in MD was 16,914 tons or 33.8 M lbs/yr

Deposition Estimates
• Total ammonia N deposition of 12,220 tons or 24.4 M lbs/year
  • 30% within 500 m of source
  • 70% within 50 km (31 miles)
Recommendations to be protective of surface waters

• In the absence of alum data, stockpiles should be covered immediately. We urge DEQ to require reporting on litter additives (i.e. acidifiers) to control ammonia emissions under this permit. Understanding Alum is not only important to understanding air quality impacts and deposition, but also has implications upon the nutrient content of litter which could be incorporated into NMPs. Including this information will help the agency manage impacts of poultry production across Virginia.

• In the presence of documentation of litter additive to stabilize ammonia, stockpiles should still be covered promptly although a longer length of time may be justifiable.

• We urge DEQ to revise the regulations to require the growers, end users and brokers to submit the data, of which they are already recording, to DEQ on an annual basis. Users are already recording this data, thus we do not believe it would be a substantive burden to submit it to DEQ once a year.