Broiler Litter: Odor and Moisture Concerns

MISSISSIPPI STATE UNIVERSITY EXTENSION

Broilers in the U.S. are raised in houses with earthen floors on litter material (often reused multiple times) composed of an initial bedding material (pine shavings, rice hulls, peanut hulls, etc.) mixed with feathers, spilled feed, water, and manure. In general, litter is a loose, friable, absorbent material that provides thermal insulation, absorbs moisture, provides cushioning from the earthen floor, and allows birds to demonstrate certain natural behaviors such as dust bathing and scratching (Collett, 2012; Shepherd and Fairchild, 2010). Good-quality litter should readily give up moisture and offer a reasonably quick drying time (Bilgili et al., 2009; Grimes et al., 2002) and should have a dedicated use after removal from the broiler house (fertilizer, soil amendment, etc.).

Often, in congested locations near feeders, drinkers, and/or exhaust fans, a compacted layer with a high moisture content (≥40 percent), referred to as "cake" (Miles et al., 2008), forms over the litter surface. Management practices should focus on preventing/limiting cake formation, as it creates issues with wet litter, ammonia (NH_3) production, and increased bacterial load in the house. Both loose, friable litter and wet cake are potential fertilizer sources for row crops or hayfields/pastureland once removed from the broiler house.

However, the conversion of nitrogen (N) compounds in manure to NH_3 is a source of environmental concern. Furthermore, lack of homogeneity (dry litter versus cake) makes it difficult to accurately estimate NH_3 volatilization from the litter surface, even though fundamental relationships among litter, pH, moisture, and uric acid N are well known (Gates et al., 1997). Let's look at odor and moisture concerns associated with broiler litter.

Odor

Odor is a natural part of broiler production resulting from aerobic and anaerobic microbial activity in the litter (Pillai et al., 2012). Unfortunately, odor from litter in broiler housing has, at times, led to nuisance complaints. Complaints continue as many former urban dwellers move to the country and subdivisions spring up adjacent to existing poultry farms. Odor itself is a complex mixture of odorous ingredients composed of volatile organic compounds (VOCs) and non-VOCs such as NH_3, hydrogen sulfide, and other compounds. There are a variety of odorous compounds released during decomposition of organic matter, making litter the primary source of odor from broiler houses. However, conditions within the litter will influence the concentration and character of odor exhausted from broiler houses (Wadud et al., 2012).

Broilers deposit moisture-laden organic matter (manure) onto the litter surface and gradually mix it into the litter during their daily activities. Some odors are from nutrients in the manure, while others are directly from the manure (Dunlop et al., 2016a). Nutrients in the litter fuel microbial decomposition processes that release these odorants (Mackie et al., 1998). In addition, the birds produce substantial amounts of heat (particularly as they near market weight) and warm the litter when they sit down. Microbial growth and diversity in litter are influenced by a variety of factors, including stocking density, original bedding material (pine shavings, rice or peanut hulls, etc.), pH, moisture content, and litter temperature. In addition, frequent wetting and drying cycles might result in a more diverse microbial population compared to chronically wet conditions (Woodbury et al., 2015).

Daily bird activities such as scratching and dust bathing expose emission sources at the litter surface, which may result in more odor (Dunlop et al., 2016a). The birds themselves have a large impact on odor emissions; houses with birds have a seven-fold higher level of VOCs compared to houses without birds (Trabue et al., 2010). It is important to characterize odor emissions from facilities while birds are present because there are distinct differences in both odorant diversity and concentrations with or without birds on the farm. This is in part because birds affect airspeed and turbulence at the litter surface, which may affect evaporation and emission rates.

Larger birds better insulate the litter surface toward the middle and end of the flock, thereby restricting airflow across the litter, which may influence litter gas flux more than seasonal conditions (Miles et al., 2008). However, seasonal changes in temperature require complementary ventilation adjustments to help birds

maintain the appropriate body temperature. Increasing the house temperature by 1–2°C can greatly increase NH_3 volatilization (Elliott and Collins, 1982).

Ventilation rate controls litter moisture, and winter ventilation rates are often less than in other seasons as growers reduce ventilation in an attempt to lessen heating costs (Gates et al., 1997). However, decreased winter ventilation leads to increased litter moisture and NH_3 levels that can threaten flock health and performance. Increased ventilation rates are often required to maintain acceptable NH_3 levels within houses. In addition, these rates are generally higher than rates required for moisture removal alone (Xin et al., 1996). Even though odor is a natural part of broiler production, keeping litter at or near 25 percent moisture content will lower odors and ammonia emissions.

Moisture

Moisture is a key factor influencing litter quality in broiler houses (Tabler et al., 2012). The higher the moisture content, the longer bacteria can survive in litter. For example, in dry litter, bacteria may only survive a few hours or days, while in wet litter, survival may extend up to several weeks. In addition, wet litter is associated with a variety of concerns such as lost performance, animal welfare, flock health, food safety, and environmental impacts (Dunlop et al., 2016b). Wet litter is often related to poor drinker/ventilation management, disease outbreaks, and digestive issues (van der Hoeven-Hangoor et al., 2013). However, wet litter can sometimes be outside a grower's control, as in the case of several days of cool, damp, rainy weather.

Wet litter has been recognized as a problem for almost 100 years (Dann, 1923) and is an issue of considerable economic and pathological importance (James and Wheeler, 1949). Unfortunately, as an industry, we have made little progress in resolving wet litter issues during the past 100 years.

Managing litter moisture is a continual process throughout the grow-out, not something to address only if litter gets wet. Moisture level at the surface of broiler litter is important but rarely measured; we generally measure average moisture of the entire litter depth. If the surface is damp, manure caking occurs, slowing the rate of drying and movement of water into the litter below the caked surface (Dunlop and Stuetz, 2016).

What happens to manure after it is deposited on the litter surface depends on litter conditions, particularly moisture content, and management practices. If litter is near the optimal moisture content of 25 percent (Collett, 2012), birds tend to work manure into the litter by scratching, dust bathing, and normal daily activity. If ventilation keeps litter loose and friable, wet manure is constantly mixed with drier litter particles, aiding the drying process. However, if litter can't absorb all the moisture being applied, birds may be unable to mix fresh manure into the litter. This can happen when:

- litter has become matted or compacted,
- litter is too wet (>35–45 percent moisture content), or
- rate of manure deposition increases (disease, water quality issues, feed issues).

Caked litter, with its higher moisture content, reduces the birds' ability to incorporate fresh manure into the litter, and a wet layer forms on the litter's surface. This highlights the importance of litter management. Unless the ventilation rate exceeds the manure deposition rate, the caked layer will grow and remain wet. Wet litter is an animal welfare issue and puts the flock at risk of higher NH_3 production, increased microbial and bacterial loads, footpad dermatitis, and other disease threats. If, however, the deposition rate is less than the evaporation rate, cake will begin to dry, and over time, the entire caked layer may dry back out. Management is critical, however, and time is short to correct the problem, so you must increase ventilation quickly if caked litter begins to form.

A host of multidimensional factors contribute to wet litter, including bedding material properties, litter conditions (friability, moisture content), bird activity, deposition rates, and ventilation program (Dunlop, 2017). In addition, litter is not homogeneous throughout its depth. The formation of cake results in a multi-layer mixture in the litter, with friable litter and caked layers having substantially different physical and chemical properties that can affect odor formation and emission (Miles et al., 2011). There are essential properties that all bedding materials should possess in order to avoid wet litter problems, including having good water-holding capacity and relatively quick drying times (Grimes et al., 2002). Following are key contributing factors and causes of wet litter and cake (Dunlop, 2017):

- Moisture wicking from earthen floor; leaks in walls/roof/ceiling
- Drinker spillage (normal)
- Drinker spillage (issues), such as mismanagement, pressure, height, design
- Abnormal manure excretion (disease, water quality, feed quality)
- Stocking density
- Increased water excretion (nutrition imbalance or ingredients, disease, increased water consumption, water quality, gut microbiota)

- Increased in-house relative humidity (exhaled moisture, wet litter, high ambient humidity, poor in-house temperature control)
- Season (winter is always a critical time for wet litter)
- Condensation
- Lighting program (light intensity and its effect on bird activity, photoperiod)
- Insufficient ventilation/air exchange (in-house humidity buildup)
- Farm biosecurity/cleaning practices
- Litter/bedding material type (some materials are more absorbent than others)
- Insufficient or excess litter depth (3–6 inches works best)
- Cool/warm litter and cool/warm in-house air
- Litter moisture content/water-holding capacity

Manure deposition and normal drinker spillage throughout a flock add as much as 0.08 gallon per square foot per day, with a cumulative total of over 2.45 gallons per square foot during a 56-day grow-out (Dunlop et al., 2015). For a 25,000 square-foot house, that's over 60,000 gallons of water. This quantity of water tends to be manageable with today's housing designs and proper ventilation management, but any additional water (from diseases, drinking water quality issues, improper diet, use of certain feed ingredients, or reduced evaporation from extended periods of high outside humidity) may result in wet litter (Dunlop, 2017).

What this means to broiler growers is that litter management has never been more important than it is today, and challenges to maintaining good litter quality have never been greater. No antibiotics ever (NAE) programs come with increased risks of coccidiosis and necrotic enteritis that can threaten litter quality; at the same time, litter quality is even more important to birds in NAE programs than to conventional birds. If drinking water bacterial, mineral, and/or pH levels are outside acceptable ranges in NAE programs, wet litter conditions can occur. Adequate ventilation rates (particularly during winter) are critical to maintaining evaporation and ensuring that litter stays loose and friable.

Don't be afraid to burn a little fuel to save litter quality. As a rule, increasing air temperature by 20°F doubles the moisture-holding capacity of air. We bring in relatively cool, dry air from outside, heat it up so that it holds more moisture than it did when it entered the house, and then remove this moisture-laden air with minimum ventilation. If fan run-time settings are adequate for bird age, moisture build-up should not occur because more moisture-laden air will be exhausted than pulled in. If settings are inadequate, moisture levels may continue to build in the house until litter becomes saturated and begins to slick over and form cake.

Summary

Odor and moisture are two of the biggest daily challenges that broiler growers face in their poultry houses. These challenges have implications for animal welfare, flock health, productivity, and the environment. Management goes a long way in addressing both odor and moisture issues. More specifically, your ventilation program is key to controlling odor and wet litter.

Many growers tend to reduce ventilation during winter to save fuel, but this can backfire if you aren't careful. You must spend time in the chicken house and constantly assess litter conditions. If the litter starts to slick over, you have two options: 1) increase the ventilation rate, or 2) lose control of litter quality. Losing control of litter quality will come back to haunt you.

It is important to increase the ventilation rate and save the litter quality, even at the expense of a little additional fuel. Remember that it is better (and less expensive) to prevent cake from forming than to try and dry litter out once wet cake has formed. In addition, better litter quality will result in improved flock performance, less footpad dermatitis, improved welfare conditions, and less environmental impact.

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By **Tom Tabler**, PhD, Extension Professor, MSU Poultry Science; **Yi Liang**, PhD, Associate Professor, Biological and Agricultural Engineering Department, University of Arkansas; **Jonathan Moon**, Poultry Operation Coordinator, MSU Poultry Science; and **Jessica Wells**, PhD, Assistant Clinical/Extension Professor, MSU Poultry Science.