Department of Animal Science

POULTRY LITTER MANAGEMENT (INSIDE AND OUTSIDE THE HOUSE)

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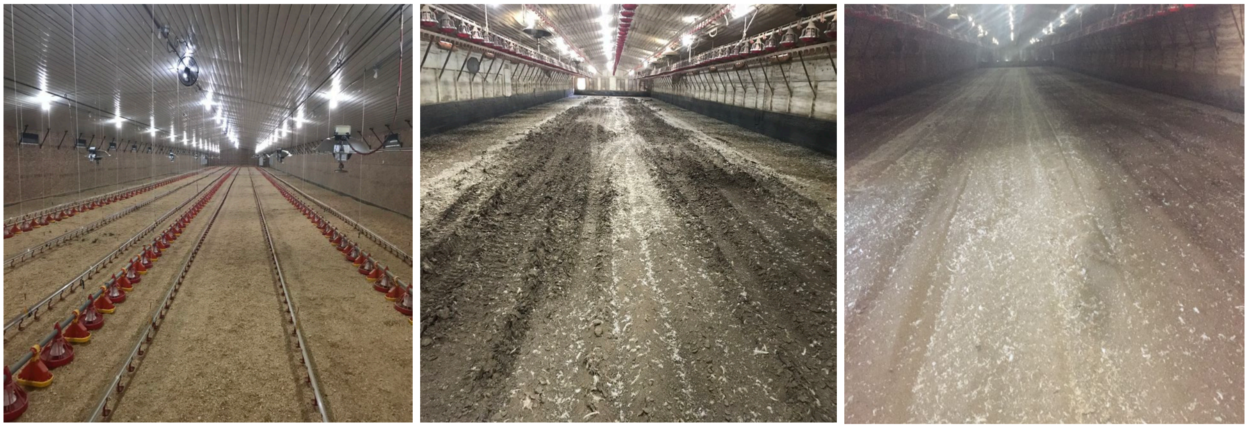
Litter is a combination of bedding material (shavings, rice hulls, etc.), bird droppings, feathers and wasted feed that serves as a surface on which poultry production occurs. Litter management is a critical part of flock management and is essential to maintain adequate bird welfare. Welfare has become a major emphasis for integrators in recent years as consumers demand to know more about how their food supply is produced. Welfare is especially important for broilers, turkeys and laying hens removed from cages and kept on litter covered floors. **Optimal litter moisture is in the range of 20 to 25 percent,** but that can sometimes be difficult to maintain, particularly in winter when growers tend to reduce ventilation rates to save on heating fuel costs. Growers should strive to maintain high quality litter throughout the year because good litter serves a variety of functions, including absorbing excess moisture from feces and the in-house environment, reducing bird contact with feces as the birds scratch and forage and work the feces in with the litter material, diluting fecal material, managing unwanted microbial activity by maintaining dry litter, insulating chicks from the cold ground, and improving paw quality. Litter production has been estimated to be roughly 2.5 pounds of litter per bird harvested (Tabler et al., 2009).

Litter production can vary from farm to farm based on house size, bird harvest weight, management practices, number of flocks per year, etc. Nutrient content can also vary greatly, underscoring the **importance of sampling and analyzing litter before it is spread** (Tabler et al., 2021). Tabler and Berry (2003) followed nine flocks of broilers on the same litter at a commercial broiler farm in Arkansas and found nitrogen (N) increased from 33.8 (1.69 percent) to 60.3 (3.02 percent) pounds per ton, phosphorus (P_2O_5) increased from 42.5 (2.13 percent) to 69.3 (3.47 percent) pounds per ton, and potassium (K_2O) increased from 36.6 (1.83 percent) to 58.3 (2.92 percent) pounds per ton on an as-is basis. Berry (1997) reported the 4-year average N, P_2O_5, and K_2O content of litter from an Arkansas commercial broiler farm cleaned out annually



Figures 1, 2 and 3. *Without proper management, ideal litter at placement (Figure 1) can lose its quality by the time the flock is harvested (Figure 2). Good litter management practices are critical to restore its quality before the next flock is placed (Figure 3).*

was 57.3 (2.87 percent), 64.9 (3.25 percent), and 50.0 (2.50 percent) pounds per ton, respectively, on an as-is basis.

Why Litter Management Is Critical

Litter management, from pre-placement, throughout the production cycle, and to the next preplacement (Figures 1, 2 and 3), is critical to avoid litter that becomes too wet or too dry, as these **conditions can negatively impact bird welfare, health, and performance**. Ideal moisture content is around 20 to 25 percent. Preventing litter from becoming too wet is much more of a challenge for most growers than letting litter get too dry. A simple and easy way to estimate litter moisture content is to grab a handful of litter and squeeze it in your hand. If the litter forms a tight ball when squeezed, it is too wet. If it is too dry, it will not adhere together at all. If the moisture content is correct, litter will adhere slightly together but will easily crumble in your hand. Litter that is too dry (<20 percent moisture) is possible and is often dusty (this may be impacted by particle size) and can lead to health problems in birds and workers, with dehydration and respiratory disease in chicks and poults, and the resulting processing plant condemnations being the primary concerns (Baker-Cook, 2023).

Wet litter is much more common and occurs when there is excessive moisture within the litter, to the degree that the litter can no longer absorb all the moisture added by the birds and the house environment. Wet litter is associated with concerns regarding flock health, animal welfare, food safety, environmental impacts and reductions in production efficiency (Dunlop et al., 2016a). Litter conditions are influenced by properties of the bedding material, addition and incorporation of manure and litter moisture content (Pepper and Dunlop, 2021). Collett (2012) defined wet litter as **having greater than 25 percent moisture** which displays compromised cushioning, insulating and water holding capacity. Welfare concerns have taken on a much greater significance for the poultry industry in recent years as consumers have become more focused on the conditions under which broiler chickens are produced. Wet litter has been implicated as a primary cause of contact dermatitis in poultry (Shepherd and Fairchild, 2010). Avoiding the consequences of wet litter is one important reason to manage the litter moisture content carefully during a grow-out (Dunlop et al., 2016b).

Litter becomes wet when the addition of water to the litter exceeds the rate of removal from the litter over time. Massive volumes of water are continually added to litter from multiple sources including excretion, drinker spillage, leaking drinkers, condensation and house leaks (Collett, 2012; Dunlop et al., 2016a; Dunlop et al., 2016b, Dunlop et al., 2016c). This highlights the importance of removing moisture from the litter using effective management practices, especially the proper amount of ventilation (Pepper and Dunlop, 2021). If added water is not removed through ventilation, the floor of the house **would be covered with water to a depth of 4 inches** by the end of a grow-out (de Gussem et al., 2015; Dunlop et al., 2015). In addition to being able to absorb moisture, litter needs to be able to readily release moisture to permit reasonable drying intervals (Grimes et al., 2002; Bilgili et al., 2009). The **beneficial attributes of litter decline as it becomes wet**. Litter moisture content varies diurnally, temporally, spatially, within the litter profile and during each grow-out period (Dunlop et al., 2016a). Wet litter has reduced friability (Tucker and Walker, 1992; Bernhart and Fasina, 2009), compresses more easily (Bernhart et al., 2010), and has reduced thermal insulation properties (Agnew and Leonard, 2003). The amount of water held by a particular litter material due to its inherent properties will determine when the litter reaches the critical moisture content for it to be defined as “wet” litter (Dunlop et al., 2016a).

Wet litter is prone to form “cake,” or a layer of cohesive, clumped litter, that develops on the surface of the litter and thereafter maintains a wet surface on top of the litter (Figures 4 and 5). Moisture at the litter surface requires special attention. Water is routinely applied at the surface from drinker spillage, bird excreta and possible absorption of humidity from the air. Water is also evaporated from the litter surface. If the surface is damp, manure crusting and/or caking occurs, which slows the rate of drying from the litter surface and the movement of water into the litter below the caked surface (Liang and Tabler, 2020). Cake formation is a consequence of wet litter and maintains surface conditions that increase the risk of welfare issues associated with wet litter, such as footpad dermatitis, which can lead to compromised weight gains and feed efficiency (Dunlop et al., 2016a). Over the course of a grow-out, the total amount of water added to the litter is more than 2,400 gal/1,000 ft^2 (Dunlop and Stuetz, 2016), which is several times more water than the litter can hold, highlighting the necessity of regular water evaporation and removal from the house using ventilation.

Ventilation is critical to **improve water evaporation at the litter-air interface** and transport it out of the house. Just as important is to continually move water in the litter to the surface so that ventilation can remove it. However, wet caked litter at the surface is heavy and compresses upon the litter below it, reducing the pore size within the litter. As a result, the movement of water molecules through the litter to the surface is substantially slowed because water must diffuse randomly through more tortuous pathways to reach the surface before it can be removed by ventilation (Pepper and Dunlop, 2021). Under-ventilating the house makes the situation worse as humidity builds up and moisture in the air slowly diffuses into the litter until the litter is saturated and cake forms. The importance of ventilating to stay ahead of cake formation cannot be overemphasized. It is very **difficult to ventilate your way out of a wet litter situation**. The key is to ventilate enough throughout the flock to prevent caked wet litter from ever forming.

Continuous water/moisture removal is critical to maintaining dry litter. Accumulating water causes litter particles to stick together (cohesion) which then requires greater energy to release the water and return the litter to a more friable state (Bernhart and Fasina, 2009). This sticking


Figures 4 and 5*. Wet litter may not appear to be an issue with market age birds in the house (Figure 4) obscuring the litter, but the problem becomes more evident when the flock is harvested. Note the tire tracks in the wet litter under the drinker lines (Figure 5).*

together first starts in areas that are more prone to becoming wetter, like under the drinkers, along the sidewalls, and near migration fences. Adequate ventilation is critical to maintain the proper litter moisture. If you under-ventilate and allow caking to begin, the birds can no longer mix the manure into the litter and the top layer of litter starts to slick over, contributing to cake formation (Miles et al., 2008a; Miles et al., 2008b). Conversely, providing adequate ventilation helps maintain good litter conditions and allows birds to work the litter by scratching, which aerates and increases the litter porosity, thereby keeping the litter loose and friable which prevents cake formation, accelerating the release of water (Pepper and Dunlop, 2021). This allows air to enter the litter, which promotes increased microbial activity that generates heat that further contributes to water release from the litter and encourages breakdown of organic material deposited with the feces (Lister, 2009).

Although not an easy task, your goal as a grower is to provide friable litter that is neither wet nor dry enough to impact flock health or welfare, that can be worked by the birds to support aerobic decomposition of manure (Dunlop et al., 2016a; Dunlop et al., 2016b, Dunlop et al., 2016c), and allows the birds to scratch and dust bathe (Shepherd and Fairchild, 2010; Collett, 2012). Good management practices are vital to maintaining litter quality while it is in the house but also to its value as fertilizer when removed from the house. Ritz et al. (2017) listed some **key points to consider concerning litter management**:

- Proper house preparation before chick placement will release ammonia trapped in the litter and is necessary to minimize detrimental house ammonia concentrations during brooding. Heating and ventilating the house 24 to 48 hours prior to chick placement will help to accomplish this.
- Be aware it may be necessary to increase ventilation rates above minimum ventilation rate recommendations to assure adequate moisture removal during the first few weeks of the grow-out, particularly if ammonia levels become too high. Begin with at least one minute out of five on your timer and decrease this ratio very carefully.
- Use circulation fans to move air within the house. The fans help litter dry by moving warm air (which can hold more moisture) off the ceiling and down to the floor.

- In negative pressure power-ventilated houses, use air inlets to bring fresh air into the house. When minimum ventilation fans are on, static pressure should be maintained at 0.05 to 0.10 inches of water so air velocity through the inlets stays within the range of 600 to 1,200 feet per minute, (though extra wide houses may require a slightly higher static pressure). This keeps cold air from dropping to the floor as it enters the house and promotes good air mixing.
- Do not be afraid to add heat to the house to facilitate moisture removal. It will pay off in the long run. As air is warmed, its ability to hold moisture increases. The combination of heating and ventilating will remove considerable moisture from the house.
- Check and manage watering systems to prevent leaks that will increase litter moisture. Adjust drinker height and water pressure as birds grow to avoid excessive water wastage into the litter.
- If leaks or spills occur and wet spots develop, promptly remove the affected litter from the house and replace it with clean, dry bedding.
- Remove cake with a housekeeping machine between flocks (tilling is not a recommended practice by most integrators). Cake removal gets excessive moisture and manure out of the house, which would otherwise contribute to elevated ammonia release from the litter in the ensuing flock. It may require some hand and shovel work, but do not leave cake in the corners that the machine can't get. De-caking machines are expensive, but if several growers share the equipment, the cost may be reduced to a reasonable level. However, if sharing equipment, make sure it is thoroughly cleaned first and then disinfected before it is moved from farm to farm.
- Make sure no moisture is entering the house from outside. Check grading and drainage around the building to ensure that storm water is being diverted away from the building and not causing a seepage issue under the pad.

The practice of growing broilers on built-up litter is quite common but comes with management challenges. The potential for issues with ammonia, disease and condemnations increases each time another flock is grown on the same litter and intensifies the challenge of maintaining an optimal in-house environment (Ritz et al., 2017). Although controlling darkling beetles can also be a challenge in built-up litter houses, field experience has shown that better flock performance can be achieved by **leaving litter in the house through multiple flocks**. This good performance may be facilitated when the old litter serves as a reservoir for the good bacteria in the litter that acts by competitive exclusion to suppress pathogens (Ritz et al., 2017). Additionally, built-up litter typically keeps the floors warmer during brooding and growing multiple flocks on the same litter increases its fertilizer value when it is removed.

Poultry Litter as Fertilizer

For generations, farmers have used animal manures to fertilize their crops (Stevenson et al., 1926). Despite often being regarded by many as only a waste product to be gotten rid of, poultry litter has significant value to Tennessee farmers as a vital source of essential plant nutrients when properly applied to soils to fertilize crops like corn, soybeans, small grains, pasture grasses and hay fields. However, it is critical to **apply litter correctly at rates that are determined by the agronomic needs of the crop**, which can be easily accomplished using the Tennessee Poultry Litter Application Worksheet (Hawkins and Walker, 2018). In most cases, this means you need a nutrient analysis of the litter so that you know the resulting nutrient application rates; you will also need a soil test on the field or pasture so you know what level of what nutrients (if any) need to be applied. Otherwise, you are just guessing. The University of Tennessee Soils Laboratory charges $15 for each soil sample submitted. Contact your local county Extension office for assistance with soil sampling. The Mississippi State University Chemical Laboratory (662-325-3428; sample submittal form), the University of Arkansas Agricultural Diagnostic Laboratory (479-575-3908; manure for fertilizer value information sheet), and Waypoint Analytical (901-213-2400; manure sample submittal form) all offer nutrient analysis of poultry litter samples. Each requires forms to accompany the litter samples. Call for current pricing schedules and information on filling out the proper forms and mailing addresses.

Historically, poultry litter has been applied to crop lands near the poultry houses, and this has led to the **accumulation of phosphorus (P) in agricultural soils** in these locations (Sharpley, 1999). This localized soil P enrichment has been linked to regional water quality degradation in some parts of the country. While land application remains the most desirable and cost-efficient use for poultry litter, the current reality is that litter must often be moved farther from the source to avoid environmental issues associated with overapplication of P, and so that it can be applied to agricultural lands that need the P application (Hawkins and Walker, 2018).

Be aware that supply and demand have a major impact on litter prices. For example, areas in West Tennessee where the demand for litter is high to go on row crop fields, the price of litter may be $50 per ton. The price may be half that or less in East Tennessee where more litter is destined for pastureland and hay fields. Litter value also varies with the price of commercial fertilizer, which spiked dramatically in recent years. Hauling distance also adds considerably to the cost per ton price. A similar situation exists in Arkansas where litter on the western side of the state where most of the poultry production is located may be $12 to $15 per ton while litter that is transported to the Arkansas Delta on the eastern side of the state to fertilize corn and rice fields may go for $50 per ton.

There are numerous benefits to using poultry litter as a fertilizer (Hawkins et al., 2024). A large portion of the input costs associated with crop production is fertilizer cost, accounting for 36 percent of a farmer's operating costs for corn (Jones and Nti, 2022). Poultry litter can offer a local, cost-effective alternative to commercial fertilizer, especially when commercial fertilizer prices are high, or quantities are limited. In addition to the primary macronutrients (nitrogen, phosphorus, and potassium (N-P-K)), poultry litter contains secondary macronutrients, micronutrients and organic matter. As a result, poultry litter can offer additional benefits to crop production and soil health beyond what commercial fertilizer can provide, thereby, making it an appealing choice for sustainable and economical agricultural practices (Hawkins et al., 2024; Pokhrel and Shober, 2024). These benefits include:

- **Local nutrient source**: Poultry litter is generated locally across the southeast and Delmarva regions of the U.S. where broiler production is centered. This helps reduce the environmental impact (i.e., carbon footprint) of crop production by diminishing the need for carbon extensive manufacturing and transportation that is associated with commercial fertilizers.
- **Gradual N release**: The slow-release nature of N in poultry litter helps reduce the potential for early-season N leaching and helps feed the crop long-term over time. Nitrogen availability during the year of application can vary greatly and ranges from 30 to 80 percent. Nitrogen is present in both organic and inorganic forms. Organic N must be mineralized (converted) into inorganic nitrogen to become available to plants. The

amount of organic N converted to plant-available forms during the first cropping year after application varies according to environmental conditions and manure handling systems. About 25 to 50 percent of the organic N becomes available during the year of application (Zhang et al., 2017), but research has shown in Tennessee the mean crop season total litter nitrogen (inorganic plus organic) availability averages 45 percent (Hawkins and Walker, 2018).

- **Secondary macronutrient and micronutrient source**: Poultry litter contains sulfur (S), a secondary macronutrient whose demand has increased due to a significant decrease in atmospheric S deposition (Pokhrel and Shober, 2024). Each ton of poultry litter can contribute 9 to 15 pounds of S (Gaskin et al., 2007). Litter can supply crop available sulfur in-season, though it should be noted this mobile nutrient will not carry over to subsequent crop years (Hawkins et al., 2024). Additionally, poultry litter contains micronutrients like manganese (Mn), boron (B), zinc (Zn), and copper (Cu), and these micronutrients are plant available and do tend to accumulate in soil and be available for future crops (Hawkins et al., 2024). By incorporating poultry litter into a sound crop nutrient management strategy, farmers can supply these vital nutrients to their crops without resorting to more costly commercial fertilizers as a source for these micronutrients.
- **Soil improvement**: As an added benefit, poultry litter contains a significant amount of organic matter and carbon, making it a useful soil amendment for improving soil health. Over time, land application of poultry litter can increase soil organic matter content and improve soil aggregation, leading to better air and water movement through the soil. Poultry litter also contains beneficial microbes and promotes soil microbial activity that facilitates nutrient cycling processes in soils and improves plant nutrient uptake.

There is **substantial opportunity for increasing the use of poultry litter**, and animal manures in general, as a fertilizer source. Manure was applied to only about eight percent of the 237.7 million acres planted to seven major U.S. field crops in 2020 (Lim et al., 2023). More acres were planted to corn (90.8 million acres) than any other crop, and a larger percentage of corn acres received manure than any other crop (16.3 percent). Corn was planted on 79 percent of the cropland that received manure.

***Figures 6 and** 7. Litter stacked more than 7 feet high is a fire danger (Figure 6). Litter stacked more than 7 feet high can catch the shed on fire (Figure 7).*

If litter is stored outside the poultry house before land application, take steps to preserve its value. If stored in the field long-term, **cover it to prevent nutrient leaching and surface runoff**, and if storing in a litter shed, protect its value by managing it to prevent a shed fire. A litter stacking shed preserves the nutrient content of the litter. It also allows litter to be stored in a secure environmental manner that protects surface and groundwater quality. Storing litter also allows flexibility in timing land application of litter to coincide with nutrient demand of the crop or forage receiving the litter (Hawkins and Walker, 2018). A litter shed is a valuable part of a poultry farm's nutrient management program. However, there is a **fire risk associated with mishandling litter** in a litter stacking shed. Never stack litter over 7 feet high at the peak or 4 feet high at the walls (Figure 6). Litter stacked too high can ignite the walls of the shed (Figure 7) if the temperature in the litter reaches the flash point of the wood or can spontaneously combust because of excess heat and methane buildup, especially if temperatures climb above 190 F. This is similar to the spontaneous combustion of hay bales that are baled too green, stored in the barn and later catch the barn on fire. Do not layer wet litter on dry litter and never compact litter in the shed (Tabler et al., 2023).

Summary

Many growers struggle with poultry litter management. High gas prices often cause growers to cut back on ventilation rates in cold weather, which is the wrong thing to do. Excess moisture associated with high in-house humidity levels that result from inadequate ventilation eventually saturates the litter, causing wet litter and cake formation. Once cake formation starts, it is all but impossible to correct the problem, even with dramatically increased ventilation. Your best bet is to ventilate enough each week to **stay ahead of litter that slicks over and forms cake**. Stay alert to changes in litter quality and take action to maintain the appropriate in-house environment for optimal flock performance. Proper litter management can improve the in-house air quality and provide ideal environmental conditions that can potentially return significant dividends from the litter, both while it is in the house and when it is removed to recycle litter nutrients into newly produced crops.

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