W1431

Poultry Litter Management Considerations

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Livestock production is under increasing pressure to reduce its environmental footprint, guarantee that meaningful welfare conditions for food-producing animals are met, and do both while remaining efficient enough to feed the ever-increasing global demand for animal protein. Poultry is currently the most consumed meat protein worldwide, driven by a combination of health, affordability, versatility, convenience, cultural acceptance and sustainability. In 2023, Alabama, Arkansas, Georgia, North Carolina and Texas together accounted for over 55 percent of total U.S. federally inspected broiler production (National Chicken Council, 2024). This tremendous growth of the poultry industry has caused growing concern about the disposal of vast quantities of poultry waste with respect to nonpoint source pollution. While poultry litter is one of the most valuable organic fertilizer sources available, excessive land application of litter (or any fertilizer source) can create environmental challenges. The primary nutrients of concern in poultry litter are nitrogen (N) and phosphorus (P).

Both N and P have value as plant food, however, if mismanaged by excessive applications, they also can cause contamination of surface and ground waters. Good litter management begins with recognizing and understanding the value of poultry litter as a resource that contains nutrients for crop production as well as the potential negative impacts that overapplying nutrients can have on the environment (air, water and soil). Nitrate leaching into the groundwater, nonpoint source P runoff into surface waters and release of pathogenic microorganisms are three main concerns associated with improper management of poultry litter. Land application of poultry litter should be managed to sustainably recycle nutrients rather than simply dispose of them (Tabler et al., 2025). Increasing environmental concerns related to agricultural nonpoint source pollution make it imperative to use poultry litter in the manner most beneficial for the environment–both on and off the farm. Zhang et al. (2017) indicated the steps to proper litter management include:

1. Determine crop nutrient requirements based on realistic yield goals and soil test data.
2. Determine the nutrient content of the poultry litter.
3. Determine the portion of litter nutrients available in the first year of application.
4. Determine litter application rate to supply crop nutrient needs.
5. Determine supplemental nutrients needed for optimum crop growth.

Following these steps will ensure that the proper amount of litter is land-applied. Avoiding excess litter applications will minimize its impact on the environment and water quality.

Nutrient Production and Composition

Livestock manure/poultry litter is rich in nutrients, including trace elements necessary for crop growth and valuable organic matter not found in chemical fertilizers. Animal manures have been used as beneficial soil amendments since the dawn of civilization and were the primary soil amendment used in agriculture until the advent of chemical fertilizers in the 1940s (Sims and Maguire, 2005). Livestock manure is an important component of animal agriculture, playing a pivotal role in its sustainability, impact on climate change and contribution to a circular bioeconomy (Chadwick et al., 2011; Glover et al., 2023). However, approximately 70 to 80 percent of N, 60 to 85 percent of P, and 80 to 90 percent of potassium (K) found in feeds is excreted in the manure (Herbert et al., 2026), making livestock manure a double-edged sword. These nutrients can replace chemical fertilizers used for pasture or crop growth, eliminating the need to purchase commercial fertilizers since plants do not distinguish between sources of nutrients. And compared to synthetic commercial fertilizer, manure contains organic carbon, which is key to maintaining soil health, including the characteristics of cation exchange capacity, soil tilth and water holding capacity (Herbert et al., 2026).

However, while manure serves as a rich source of nutrients essential for crop growth, improper management can lead to negative environmental consequences, including greenhouse gas emissions (Sadeghpour et al., 2017), water quality impairment (Kleinman et al., 2012) and odor issues (Feilberg Tavs Nyord et al., 2011), particularly in areas with concentrated animal populations, where limited land availability for proper manure application can result in excessive application (Dell et al., 2022).

The nutrient value of manure depends on numerous factors. Among these are animal species, feed ration, the amount of bedding material and water added or lost, the method of collection and storage, and the method of land application. The availability of nutrients and efficiency of utilization of these nutrients by a crop is also influenced by soil and climate conditions. These conditions affect the microbial activity responsible for decomposition of manure and other sources of organic matter within the soil (Herbert et al., 2026). As a result, the use of raw manure comes with its own set of challenges. Manure's low nutrient-value-to-mass ratio and typically high moisture content make transportation expensive and logistically challenging (Van Horn et al., 1994). Therefore, it becomes critical to address not only the local manure surplus but also the lack of capacity to transform the waste into a valuable resource within the framework of the circular bioeconomy (Åkerman et al., 2020; Arshad et al., 2022)

The U.S. poultry industry generates about 14 million tons of broiler litter annually (Ashworth et al., 2020; Prasad et al., 2025). Broiler litter is a combination of chicken feces, urine, bedding material (such as pine shavings, rice hulls, peanut hulls, sawdust, etc.), spilled feed and feathers. Most broiler litter is applied on agricultural lands such as pastures, hayfields and row crop fields as a soil amendment. It is a valuable organic fertilizer for sustaining soil fertility and supporting plant growth. Broiler litter typically contains 11 essential plant nutrients: N, phosphate (P_2O_5), potash (K_2O), calcium (Ca), magnesium (Mg), manganese (Mn), boron (B), sulfur (S), copper (Cu), iron (Fe) and zinc (Zn) (Prasad and Stanford, 2019). However, the nutrient concentrations in broiler litter are highly variable and depend on numerous factors such as bird age, number of flocks grown between cleanouts, type of diet fed, litter age, amount and type of initial bedding material, litter pH and moisture content.

A survey analyzing the nutrient content of broiler litter samples collected from poultry houses across Mississippi revealed significant variability in nutrient composition (Tabler et al., 2015). Table 1 provides the range of nutrient concentrations in broiler litter collected from 12 individual complexes at 210 different broiler houses representing six poultry integrators. The analysis revealed that N content in litter ranged from 39 lbs/ton to 61 lbs/ton, with an average value of 47 lbs/ton. Similarly, P_2O_5 content varied between 43 lbs/ton and 89 lbs/ton, with an average of 69 lbs/ton. The K_2O content ranged from 57 lbs/ton to 67 lbs/ton, with an average of 61 lbs/ton. These findings indicated a similar variability pattern with later surveys in Kentucky (Shockley, 2022) and Alabama (Prasad et al., 2025). The water extractable P in the Tabler et al (2015 study ranged from 5 to 13 lbs/ton, with an average of 9 lbs/ton (Table 1).

Table 1. Effect of division on number of flocks of broiler litter, litter pH, litter moisture percent, N, P_2O_5, K_2O, and water-extractable phosphorus (WEP)[1].

					lbs/ton on as is basis			
Division	# of farms	# of flocks	pH	Moisture %	N	P_2O_5	K_2O	WEP
1	18	7.28^{c}	7.48^{ab}	24.46^{efg}	44.08^{bc}	43.13^{c}	61.84^{ab}	9.58b^{cd}
2	20	7.95^{c}	6.67^{f}	25.35^{defg}	44.42^{bc}	50.78^{c}	61.94^{ab}	6.59^{f}
3	18	5.94^{c}	7.61^{a}	23.85^{gf}	38.76^{c}	52.53^{c}	59.94^{ab}	4.95^{f}
4	20	8.05^{c}	7.19^{cd}	27.23^{bcd}	46.68^{b}	55.23^{c}	60.23^{ab}	13.38^{a}
5	4	11.25^{c}	7.27^{bc}	27.11^{def}	47.42^{b}	73.49^{b}	60.16^{ab}	9.40^{cd}
6	10	22.40^{b}	7.12^{cd}	26.39^{cde}	47.08^{b}	77.24^{ab}	57.37^{b}	8.00^{de}
7	10	10.50^{c}	6.84^{ef}	28.95^{ab}	49.46^{b}	74.78^{b}	59.19^{ab}	9.52^{bcd}
8	16	12.87^{c}	7.14^{cd}	25.73^{def}	45.52^{b}	75.82^{b}	66.86^{a}	10.83^{bc}
9	7	34.43^{a}	6.81^{ef}	26.71^{cd}	46.61^{b}	78.65^{ab}	57.02^{b}	10.45^{bc}
10	12	12.58^{c}	6.71^{f}	27.92^{ab}	49.84^{b}	85.99^{ab}	59.67^{ab}	10.47^{bc}
11	18	25.22^{b}	6.99^{de}	28.37^{g}	60.85^{a}	89.30^{a}	64.73^{ab}	11.29^{b}
12	5	6.20^{c}	7.10^{cd}	30.26^{a}	48.56^{b}	75.78^{b}	67.44^{a}	6.16^{f}
Average	13.72	13.72	7.08	26.86	47.44	69.39	61.37	9.22

^{abcdefg}Means within a column not sharing a common subscript differ significantly (P<0.05).

[1]Adapted from Tabler et al. (2015).

Land application offers the best solution to manage the enormous amounts of manures generated on U.S. poultry farms each year. However, in Tennessee, producers are required to meet all field-specific Tennessee NRCS conservation objectives and standards, including recommended manure application setbacks and proper timing of manure applications. Areas contained within minimum application setbacks (e.g., sinkholes, wellheads, gullies, ditches, etc.) must receive nutrients consistent with the setback restrictions (NRCS, 2019). Refer to Table 2 for recommended setback guidance. For additional guidance on litter land application management, refer to the University of Tennessee Extension litter land application worksheet (Hawkins and Walker, 2018).

Table 2. Recommended Tennessee non-application buffer setback widths#[1].

Object, Site	Situation	Buffer width (ft) from Object, Site
Well	Located upslope of application	150
Well	Located down slope of application site provided conditions warrant application	300
Waterbody[2]	Predominate slope < 5-8% with good vegetation[3]	35
Waterbody[2]	Predominate slope 5-8% with good vegetation[3]	50
Waterbody[2]	Poor vegetative cover or predominate slope >8%[3]	100
Waterbody[4]	Natural Riparian Buffer between waterbody and land application area[4]	60
Public road	Irrigated wastewater or solids applied with spreader truck	50
Dwelling	Other than producer-owned	300
Public use area	All	300
Property line	Location downslope of application site	30

#Adapted from NRCS-TN Code 590 (2019).
[1]Research has shown that forested or forest/grass buffers are more effective at removing nutrients and sediment than a grass buffer. Grass buffers are more effective at removing nitrogen. Every effort should be made to reduce phosphorus movement inputs at their sources.
[2]Waterbody includes pond, lake, stream, wetland, or sinkhole. "Open" sinkholes should be protected the same as a well. Where sinkholes are not "open", a buffer width should be established that provides optimum filtering above the depression. Stream includes both perennial and intermittent streams.
[3]Good vegetation refers to a well-managed, dense stand that is not overgrazed.
[4]According to TN Department of Environment and Conservation (TDEC) Rules for Animal Feeding Operations Chapter 1200-04-05-.14, for new CAFOs that are located adjacent to exceptional Tennessee waters and outstanding natural resource waters (as identified by TDEC), leave in place a minimum 60-foot natural riparian buffer between the stream and the land application area.

In addition, producers using poultry litter as a fertilizer should be aware of the potential environmental risks associated with its application. For instance, applying litter annually for more than five consecutive years can lead to P accumulation in the soil, which may negatively impact water quality (Prasad et al., 2025). Routine soil tests should be conducted to monitor extreme P buildup. In addition, fall or winter litter application to fallow fields should be avoided, as rainfall can cause nutrients to dissolve and be carried away in surface water or leach into the soil, reducing effectiveness, increasing the environmental risk and lowering the economic value of litter. Hawkins et al. (2025) indicated that applying litter to soybeans may be perceived by some as a poor agronomic practice because most research indicates that N applications to soybeans will not improve agronomic returns.

However, when litter is applied to soybeans at planting, this risk is minimal because soybeans will utilize the litter N early in the season instead of relying entirely on N fixation (Hawkins et al., 2025). Prasad et al. (2025) indicated the ideal time to apply poultry litter is 10 days before spring green-up in the case of pasture and 10 days before planting a row crop. The nutrients in litter are available as both fast-release and slow-release. The fast-release components provide nutrients within a matter of 10 days, whereas, the slow-release nutrients become available over months or even years. Most producers should take advantage of the fast-release nutrients by synchronizing the litter application timing close to planting time or spring green-up.

Effects on Water Quality

The common method of land application for poultry litter is broadcasting without incorporation. Unfortunately, the same nutrients that make poultry litter a valuable organic fertilizer can, under some circumstances, be detrimental to the quality of groundwater and downstream surface water. Poor nutrient management can lead to water quality problems. Poultry litter and other animal manures contain N, P, organic matter and pathogens that are considered four primary components that affect water quality. Without proper management, these potential pollutants may enter water resources by surface runoff, leaching and deposition from the atmosphere.

Nitrogen is one of the basic components of proteins, which are a part of all living things. Protein (and therefore N) is usually provided to animals through the feed. However, animals use only a portion of the N in their feed for growth and body maintenance and to produce meat, milk or eggs. The remaining protein is excreted as waste. Nitrogen availability during the year of application varies greatly and can range from about 30 to 80 percent (Zhang et al., 2017). Nitrogen in poultry litter exists in two forms labeled as organic or inorganic. Organic N includes urea, undigested proteins in manure and feed, and other animal waste products such as feathers and hair. Organic N must be converted (mineralized) into inorganic N to become available to plants. Most of the N in poultry litter is in the organic form (approximately 89 percent) with about 9 percent in the form of ammonium and 1 to 2 percent in the form of nitrate (Gaskin et al., 2007). 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 practices. About 25 to 50 percent of organic N becomes available during the year of application (Zhang et al., 2017). All the inorganic N (about 10 percent) is readily available to plants. Inorganic N includes ammonia, nitrate and nitrite.

Table 3 shows the approximate availability of N in the first three years after application. Take note of the fact that more N is available for plant use if the litter is incorporated into the soil soon after application. Incorporation reduces ammonia volatilization and nutrient runoff losses. Different forms of N present different risks to water quality. Ammonia concentrations exceeding 2 parts per million (ppm) can lead to fish kills (Ogejo, 2024). Nitrates above 10 ppm in drinking water may cause blue baby syndrome when consumed by infants. Excess N can cause eutrophication in surface water.

Table 3. Estimated poultry litter N availability based on application method[1].

Year after application	Land-applied on surface	Soil incorporation
First year	50%	60%
Second year	15%	15%
Third year	6%	6%

[1]Adapted from Zhang et al. (2017).

Fewer studies have been conducted on the P and K availability in poultry litter; however, availability is about 80 to 100 percent of the P and K available in commercial fertilizer (Zhang et al., 2017). Animals require P for bone development and optimum production. It is also an essential nutrient for plant growth and development. Animal manure that is land-applied to supply nutrients for crop growth typically does not contain a nutrient profile that matches the nitrogen-to-phosphorus (N:P) ratio required by crops. As a result, if poultry litter is applied to satisfy the N requirement of a crop, P is over-applied and soil P level will increase over time. When soils become saturated with P, the potential for offsite movement increases in runoff water. Phosphorus typically moves with runoff water and soil erosion. It can be attached to minerals containing iron, aluminum and calcium or to organic matter such as crop residue, bacteria in the soil or litter, or decaying organic matter.

Organic matter in poultry litter can be a valuable environmental resource if managed properly; however, if litter reaches a water body or moves off-site by water runoff, organic matter can become a pollutant. Organic matter degrades rapidly in water and may result in oxygen depletion in water bodies. Organic matter is primarily transported into surface water by runoff. Rarely does organic matter leach into the soil.

Pathogens include microorganisms such as viruses, bacteria and protozoa that cause infection or disease. Disease-causing microorganisms may be present in poultry litter. Therefore, it is important to maintain adequate separation between the potential source of pollutants and water bodies. Pathogens are most likely transported to water through surface runoff and erosion or by direct animal access to surface water. Streams and lakes used for drinking water and recreational purposes provide the greatest opportunities for transmitting these pathogens. Humans may be infected if they consume crops irrigated with untreated wastes that contain pathogens.

However, pollution with any of these substances is not an inevitable consequence of poultry farming. Pollution occurs only when poultry litter is mismanaged, i.e., when litter is land applied in quantities that exceed plant needs or when the ground is wet or frozen. As a result of such application, potentially contaminating substances become available to the environment. If they become detached from the site, by being adsorbed to sediments or dissolved in water, the potential exists for them to be transported off-site. Transport occurs when contaminants in animal waste (the unused nutrients, bacteria or other elements in the litter) are released to surface water or infiltrate beneath the soil surface in groundwater recharge areas.

Incentivizing Manure-based Products

Nutrient recovery technologies (i.e., mechanical, chemical and biological separation) are highly effective in transforming raw manure into valuable, nutrient-dense manure-based products. The process involves extracting and concentrating essential nutrients, such as N, P, and K, to produce a high-value fertilizer that is more suitable for transporting long distances and application on diverse crops. Each of these technologies comes with its own set of advantages and disadvantages. However, by harnessing the power of advancements in manure processing technologies, we can mitigate the environmental challenges associated with manure management and unlock the potential for creating valuable manure-based resources. These resources contribute to a circular bioeconomy by transforming waste into wealth, facilitating the decoupling of economic growth from the increasing reliance on virgin resources through the closure of material loops (Åkerman et al., 2020).

Policymakers should 1) consider financial incentives for the adoption of manure management practices that reduce environmental threats and 2) explore the possibility of providing tax credits to farmers who adopt responsible manure management practices. Incentives act as catalysts for encouraging the beneficial utilization of agricultural by-products (e.g. poultry litter), simultaneously enhancing environmental sustainability and agricultural efficiency. Establishing a policy framework that incentivises farmers, including row crop farmers and specialty crop producers, to choose manure-based products to at least partially replace synthetic fertilizers is a critical first step in promoting advanced manure-processing systems and advancing sustainable agriculture and mitigating the environmental impact of conventional manure processing (Sadeghpour and Afshar, 2024). Aligning incentives with environmentally friendly choices empowers policymakers to guide the agricultural sector towards a more sustainable future. This alignment not only encourages responsible manure use but also reinforces compliance with existing environmental regulations. Integration with broader sustainability initiatives, such as carbon sequestration goals or water quality standards, ensures that promoting manure use becomes an integral component of a larger environmental agenda.

Manure and manure-based products contribute to soil carbon enhancement through various pathways, including increased organic matter input, improved aggregate formation and stabilization (Mikha and Rice, 2004) and microbial carbon inputs (Sayre et al., 2023). Some may argue manure and compost applications merely redistribute carbon rather than sequester it, however, long-term studies have demonstrated significant benefits of manure products in boosting soil carbon sequestration (Liu et al., 2013; Zhang et al., 2015; Tautges et al., 2019; Li et al., 2020). Manure management practices that contribute to carbon storage and sequestration often align with other environmental benefits, such as improved water quality and biodiversity conservation (Phelan et al., 2024).

Neighbor Relations

Livestock farming, including poultry production, creates several potential nuisances, including odors, dust, flies and noise. Be cognizant of these nuisances and the potential concerns neighbors may have regarding your poultry farming operation. The demographics of farm country are changing, and what used to be isolated rural landscapes are becoming increasingly urbanized. Public awareness of environmental issues is increasing. As a result, farm and non-farm neighbor conflicts are also increasing. Non-farm communities often complain that farming activities near their homes affect their quality of life. Increasingly, farmers are being forced to consider social as well as air quality concerns when developing manure management plans (Ogejo, 2026). While all fifty states have right-to-farm laws that provide some degree of safeguards and security to agricultural producers, the level of protection these statutes provide can differ significantly across the U.S.

Recognize that large numbers of animals concentrated near non-agricultural residents will produce odor and visual issues related to confined feeding operations. Do not let issues with litter or manure management get out of control. Make neighbors aware of your farming operations and activities, especially related to your litter application schedules. Communicate regularly, and, if the neighbors are having a special event at their home that conflicts with your spreading of poultry litter, work with them as best you can to accommodate their schedule. Delay land application of litter for a day or so to work around their plans if possible. Keep in mind that people are usually more accommodating if issues are worked out ahead of time, including the things they do not particularly care about, like spreading litter. In most cases, people will tend to give you a little more latitude with things they do not like if you make a good faith effort to address their concerns and work with them on activities that relate to your farming operation.

Summary

The transformation of manure and manure products like poultry litter from a potential pollutant to a valuable resource represents a complex challenge that requires a comprehensive strategy. Adopting a holistic approach involves embracing technological innovations, providing incentives for farmers, enacting supportive policies, and emphasizing continued research and education. Understanding and managing poultry litter nutrient variability is essential to optimizing agronomic results and taking advantage of litter's many benefits. By harnessing the potential of poultry litter as a valuable resource, farmers not only mitigate environmental risks but also clear the way for a more resilient and sustainable agricultural system. Poultry litter can be a double-edged sword and must be managed correctly to avoid environmental challenges and conflicts with neighbors; however, the journey towards a circular bioeconomy that includes sustainable poultry litter management practices signifies not only an environmental success but also a cornerstone for a more secure, sustainable, and economically vibrant agricultural tomorrow.

Online Resource

For additional guidance on litter land application management, refer to UT Extension publication W796 Litter Land Application Management: **solutions.tennessee.edu/publication/W796/**

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