Utilization of Poultry Litter Waste for Organic Manure Production

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Introduction

Poultry litter, a heterogeneous mixture of poultry excreta, bedding materials such as wood shavings, rice husk, or straw, feathers, and residual feed particles, is widely recognized as a nutrient-rich organic by-product with considerable agronomic potential. It contains substantial amounts of essential macronutrients, particularly nitrogen, phosphorus, and potassium along with calcium, magnesium, and trace minerals such as zinc, copper, and manganese, making it a valuable soil amendment. The growth of the global poultry industry, driven by rising demand for affordable animal protein, has intensified broiler and layer production systems, resulting in concentrated poultry operations that generate large quantities of litter. If managed appropriately, poultry litter can enhance soil fertility, improve organic matter content, promote microbial diversity, and reduce reliance on synthetic fertilizers, thereby contributing to sustainable crop production and circular nutrient economies. However, improper handling or excessive application can pose environmental risks, including nutrient runoff, water eutrophication, ammonia volatilization, and pathogen transmission. Therefore, its utilization requires scientifically informed processing methods such as composting, pelletizing, or co-amendment with biochar or vermicompost to stabilize nutrients and mitigate hazards. With proper management, poultry litter represents not just a waste by-product but a renewable agricultural resource capable of improving productivity while supporting environmental stewardship.

Nutrient Composition and Agronomic Value

Typically, poultry litter contains about 4.5–5.5% nitrogen (N), 2.5–2.8% phosphorus (P), and 2.0–2.3% potassium (K), along with substantial amounts of calcium (Ca), magnesium (Mg), and essential micronutrients such as zinc (Zn), copper (Cu), manganese (Mn), and iron (Fe). Approximately, 75–80% of the nitrogen is present in organic form, requiring mineralization before plant uptake. Consequently, only about 45–55% of the total nitrogen becomes available to crops during the first year after application, with the remainder contributing to long-term soil fertility (Hemavarshini et al., 2025).

Processing Methods for Poultry Litter

1. Composting and pelleting

- *Windrow composting* – Poultry litter is arranged in long rows (windrows) to promote aerobic decomposition. As the internal temperature rises to ~60–70 °C, pathogens are destroyed, odours are reduced, and the material stabilizes.
- *Pelleted composting (closed systems)* – Systems such as the Hosoya method produce pathogen-free, nitrogen-stable granules. Compared to open composting, closed systems minimize ammonia (NH_3), carbon dioxide (CO_2), and greenhouse gas emissions.

2. Co-amendment with biochar or vermicompost

- *Biochar co-composting* – Integrating biochar (10–20% by weight) into poultry litter during composting can reduce ammonia volatilization by up to 64%, stabilize nutrients, boost microbial activity, and

improve crop yields (e.g., maize, bermudagrass) as per Zhang et al. (2022).
- *Vermicomposting* – Using earthworms to process poultry litter enhances aeration, increases microbial diversity, and produces stable humus-like castings readily available for plant uptake.

3. Biodrying
- A rapid pre-treatment that lowers moisture content by utilizing composting heat and aeration. Often used before composting or pelletizing, biodrying reduces weight and volume, lowering transportation and handling costs.

Best Practices and Recommendations

Nutrient management
- Base application rates on soil phosphorus (P) test results, not solely on nitrogen (N) needs, to avoid P accumulation and runoff.
- Apply litter evenly using calibrated spreaders and monitor long-term soil P indices.

Processing and amendment
- Compost or pelletize litter to reduce pathogens and nitrogen volatilization; closed composting systems retain more N and release fewer greenhouse gases than open windrows.
- Co-compost or mix with biochar (10–20% by weight) to limit nutrient losses, improve stability, and enhance soil carbon sequestration.
- Use biodrying before composting or pelletizing to cut transport costs and improve processing efficiency.

Hygienic safety
- Maintain compost temperatures ≥ 60–70 °C for several days to ensure pathogen elimination. Composting durations range from several weeks to months depending on the method.
- For raw litter application, follow safety intervals: ≥ 120 days before harvest of ground-contact crops and ≥ 90 days for above-ground crops to minimize microbial risks.

Environmental monitoring
- Regularly test soils for phosphorus and heavy metals. If P levels become excessive, rotate land use or transport manure to other sites.
- Comply with regional regulations, for example, in the UK, large-scale poultry manure may be classified as industrial waste, requiring specific disposal and environmental protection measures.

Life Cycle Environmental Assessment (LCA) of Poultry Litter Utilization

Crop-based LCA compared broiler-litter-based pelletized compost (CPPL) with conventional chemical fertilizers. At the production stage, CPPL exhibited similar global warming potential (GWP) but higher acidification and eutrophication impacts (Carneiro et al., 2024). However, when applied to maize, CPPL demonstrated lower whole-system environmental impacts than chemical fertilizers, highlighting its long-term sustainability advantage.

India-relevant LCA scenarios

Indian trials show that composting broiler litter with biochar or mushroom bran optimizes energy use (~3.2 kWh/Mg electricity and 2.85 L diesel per ton), reduces emissions, and slows moisture and nutrient losses compared to baseline models using tobacco residue or similar amendments.

Risks and constraints
- *Phosphorus accumulation* – Application rates based solely on nitrogen needs may overload soils with P, increasing the risk of runoff and eutrophication.
- *Heavy metal build-up* – Trace elements such as Cu, Zn, and As can accumulate in soils and forage crops; usually within permissible limits but requiring periodic monitoring.
- *Ammonia emissions* – Losses during storage and composting reduce nutrient value and contribute to environmental hazards; mitigated through closed composting systems or biochar co-amendments.

Benefits
- Poultry wastes typically contain higher concentrations of nitrogen, calcium, and phosphorus than wastes from other livestock species, providing a strong incentive for utilization.

- Nitrogen losses from poultry droppings can be minimized by co-composting with coir pith, producing a stable, nutrient-rich organic amendment.
- Proper composting ensures organic nutrients are readily available to crops while reducing ammonia volatilization and pathogen risks.

Conclusions

Poultry litter is a nutrient-rich, cost-effective alternative to synthetic fertilizers, offering substantial benefits for soil health, crop productivity, and farm economics. Advances in processing such as composting, pelletizing, and biochar amendment, enhance nutrient efficiency, reduce emissions, and limit contamination risks. Long-term soil nutrient monitoring and responsible application strategies are essential to maximize benefits while safeguarding environmental quality.

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