A Review of Literature Concerning Odors, Ammonia, and Dust from Broiler Production Facilities: 4. Remedial Management Practices

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Primary Audience: Extension Specialists, Poultry Scientists, Poultry Farm Managers

SUMMARY

Increased attention by regulatory agencies on agriculturally generated atmospheric pollutants necessitates consideration of emission reduction strategies in broiler facility management. Various remedial activities exist that can greatly reduce off-site transport of odorous compounds, ammonia and dust; however, descriptive collections of the different technologies remains limited in the literature. Therefore, this review aims to collect research findings into a comprehensive examination of both established and innovative remedial activities. Furthermore, this paper identifies management practices that warrant further research or require investigation of technology transfer potential from other livestock production types to broiler operations. Installation and operating costs are listed when available to provide insight into the economic viability of a remedial activity based on air quality needs. Used in conjunction with an appropriate pollutant management plan, the reviewed remedial practices may prove to abate odor, ammonia, and dust problems originating from broiler operations.

Key words: ammonia, biofilter, chemical amendment, dust, negative air ionization, odor, oxidation

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DESCRIPTION OF PROBLEM

Concern over nuisance odor generation by broiler operations in regions experiencing population growth has prompted increased emphasis on controlling the impact of atmospheric pollutants on neighboring areas. Although certain management practices can be used to reduce emissions, a certain level of degraded air quality by broiler operations remains inevitable. A variety of remedial activities exist that reduce transport of pollutants to sensitive areas. This review jointly imparts abatement methods for odor, ammonia, and dust, as these remedial techniques often alleviate associated nuisance levels and human health risks concurrently.

The association between odor generation and elevated dust and ammonia concentrations remains uncertain with conflicting studies [1, 2, 3, 4], but often steps taken to reduce one pollutant will effectively reduce the others as well. For instance, many remedial activities reduce malodors by removing suspended dust particles

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that can act as carriers of certain odor-producing compounds [1, 5, 6, 7]. Although correlations between ammonia and odor have not been established, efforts to reduce ammonia emissions can have a corresponding effect on odor generation. Reduction in ammonia may limit odor production, in that ammonia acts as an odorant independent of other odorous compounds, while concurrently improving broiler health, as ammonia stress can irritate mucous membranes and the respiratory tract [8]. Mitigating measures can, therefore, be selected to simultaneously reduce elevated concentrations of odor, dust, and ammonia. This relationship among odor, dust, and ammonia necessitates inclusion of a broad field of research in this review that may not explicitly consider a specific pollutant. As odors are often of primary concern, this review will frequently address technologies intended to reduce odors with references to dust and ammonia being either overt or implied.

Cost constitutes a primary factor when adopting atmospheric pollutant control technologies. Broiler producers should perform a cost-benefit analysis based on the level of abatement necessary and site-specific factors when selecting remedial methods. Human and broiler health concerns also require examination when selecting a remedial practice. For instance, although ozone can provide an effective odor abatement technique, high ozone exposure may exceed current permissible exposure limits.

Research on available odor, ammonia, and dust abatement techniques is often lacking. Moreover, available data often focus on other livestock operation types. Although inherently different from broilers, these systems exhibit many of the same problems concerning emissions. Further research into technology transfer may determine more cost-effective options or reduce health risks.

Broiler operations can adopt a single remedial activity or use several in series to reduce off-site pollutant transport. Determining the most effective abatement method depends on site-specific factors, including size of operation, distance to sensitive areas, cost limitations, and aerial pollutant generation.

ABATEMENT TECHNOLOGIES

Scrubbers

Air scrubbers provide an effective treatment method for removal of odorous constituents from exhaust air. Deodorization results from the transfer of airborne compounds to a liquid phase by passing the gas flux through an aqueous solution—typically water. This incorporation into the liquid phase may take place as either a physical absorption phenomenon or through a chemical reaction mechanism.

Scrubbers can consist of towers packed with a contact media, gas, or liquid-driven venturi systems, or spray towers depending on facility conditions. Packed tower technology generally provides more effective odorous compound removal; however, venturis and spray towers offer a more instantaneous removal of dust particles. Packing material can be characterized by the surface geometry or the connectivity with neighboring material. This allows for either a centrifuge effect that leads liquids toward the walls (e.g., Raschig and Pall rings) or the creation of an active surface (e.g., Tellerettes). Packing scrubbers can follow a cross-current (water drawn into material from the side) or counter-current (air drawn up from the bottom of the washer) principle.

Following the transfer of odor-causing constituents from the exhaust air to the wash-water, many of the compounds can undergo microbial degradation. Organic compounds common to poultry operations (e.g., acetic acid, phenol, indole) serve as a carbon source, and ammonia serves as a nitrogen source. Examples include the oxidation of ammonia to nitrate by nitrifying autotrophic microorganisms (with a corresponding pH drop) and the aromatic compound decomposition by *Pseudomonas* and other bacteria. Van Geelen and van der Hoek [9] demonstrated microbial breakdown occurred in wash-water by documenting the disappearance of organic compounds, the formation of nitrate, and a decrease in pH.

Initial scrubber designs presented a number of limitations to poultry operations [10]. Excessive total cost presented the greatest shortcoming for these systems, as extensive duct-work was required for early systems. Technical limitations included the need for large pumps, frequent clogging of spray nozzles by coarse particles, inconsistent water flow, complicated maintenance, and variable efficiency. Continued research has led to improved air scrubber designs.

Van Geelen and van der Hoek [9] experimented with a number of air scrubber materials intended for use by poultry operations for odor removal. A honeycomb-shaped material made of paper impregnated with phenolresin was found to cause difficulties during cleaning, as pieces of paper became loose. A loosely packed Tellerettes packing and a number of proprietary materials packed about 0.5 m deep provided a 60 to 85% smell reduction according to organoleptic and chemical analysis. Ventilation rates were approximately 6,000 m^3 of air/h (212,000 ft^3/h) and water circulated at 10 m^3/h (350 ft^3/h). Activated sludge was added to the wash water to stimulate microbial growth to promote breakdown of odorous compounds. The authors recommend a portion of wash-water be discharged to prevent accumulation of solid material and salts.

Zeolite, a group of minerals that form a crystalline, hydrated aluminosilicate structure with exchangeable constituent cations, exhibits chemical properties that present an effective packing material for air scrubbers. Koelliker et al. [11] examined the use of clinoptilolite in poultry houses to reduce ammonia concentrations. Fine (1.17 to 2.36 mm) and coarse (2.36 to 4.70 mm) zeolite beads were used in 6 stacked trays. The device removed between 15 and 45% ammonia despite a contact time of less than 1 s. The economic incentive for this design was emphasized due to reduced ventilation requirements with reduced ammonia levels.

Air scrubber design considerations should include [12]

1. Water reservoirs located within the unit to prevent freezing.
2. Inclusion of an easily accessible water addition and removal system.
3. Removable packing to enable fans to operate freely during low-odor emission periods.
4. Design simplicity.

Future research needs include comparison of different packing materials and different flowrates of wash-water with respect to odor reduction and system costs.

Misting Screens

Miner and Stroh [13] noted the use of a water screen using an irrigation pipeline for odor control around agricultural operations. Similar to scrubbing systems, this method may provide a less expensive mitigation method if installed at broiler house exhaust outlets. Few citations were found using this technique in agricultural operations; however, this method has been used effectively around municipal waste treatment facilities.

Proprietary treatments can be dispersed around odor-generating areas as a fine mist. Initial designs used water sprayers to remove odorous compounds from the air, but more recent advances incorporate essential oils derived from plant extracts to neutralize organic amines, mercaptans, and disulfides. Odor complaints have been negligible from an adjacent housing development after mist sprayer installation at the College Station, Texas, municipal wastewater treatment plant [14]. Banks of spray nozzles are often required, but the systems are typically quiet and unobtrusive. Current investigations include use of enzymes to provide a steeper dose response curve by rapidly changing odorous compound characteristics.

Filters

Filters provide an alternative method to air scrubbers for broiler operations. Filter technology has been used for many years, with fibrous filters being the most common air cleaning devices [15]. Dust and associated odor-causing compounds become entrapped in fibers through a number of physical mechanisms. Carpenter at al. [16] found that traditional filter systems used in broiler operations reduced dust content by up to 50%.

Dust and feathers in broiler facilities can easily clog traditional filter systems. Clogging can become problematic to the point that poultry operators were found to forego filters over air-conditioning units rather than deal with the required maintenance [17]. To overcome such problems, filters should be placed in series, with the first (i.e., upstream) filter consisting of a fairly coarse strainer primarily intended to remove feathers.

Biofilters

Biofilters, which operate by forcing odorous air through a moist packing material, may provide an alternative to traditional filter systems for broiler facility dust and odor emission reduction. These filters provide a medium for microbial populations, which aid in converting odorous compounds to benign byproducts, such as water, carbon dioxide, and minerals. Research has shown that even stable compounds, such as phenols and long-chain polymers, can be degraded in these systems [18].

Substrate for biofilters often consists of natural porous material, including soil, compost, peat, activated carbon, municipal waste, bark, tree trimmings, and leaves. Amending the media with clay material can increase the reactivity and extend the life of the biofilter [19]. Literature reviews have shown that moisture content typically varies between 40 and 80% [20], and pH should be maintained in a range of 7 to 8 [19]. Biofilter design should also consider surface load and velocity, air distribution, retention time, temperature, and humidity, as these factors influence maintenance costs.

Biofilter parameters may differ depending on whether the target odor constituent consists of ammonia or other odorous compounds. Air retention time acted as the primary variable in ammonia reduction with lower airflow rates (i.e., increased retention time) providing better ammonia reduction [21]. Initial odor concentration before entering the filterbed, however, acted as the main influence for reduction of other odorous compounds, as determined using an olfactometer [21]. Thus, biofilters may be considered for use in conjunction with other management practices to optimize odor reduction. The University of Minnesota Extension Service [22] provides a guide for biofilter design.

Properly designed systems exhibit significant odor reduction with removal rates of 99.8, 99.0, 89.5, and 98.1% for hydrogen sulfide, methanethiol, dimethyl sulfide, and dimethyl disulfide, respectively [23]. However, biofilters installed in a 20,000-bird broiler house would require 1,500 m^3 (nearly 53,000 ft^3) of packing material assuming a maximum airflow of 80 m^3/s [nearly 170,000 ft^3/min (CFM)] with a residence time of 20 s [20]. In addition, Nicolai and Janni [24] recommend biofilters used at poultry facilities should be installed with dust removal equipment, as dust accumulated on fans.

Biofilter cost analysis remains disparate [7, 25]. Cost estimates in 1992 were $0.34 [26] per broiler, while thermal incineration, catalytic incineration, carbon adsorption, absorption, dispersion via chimneys, and bioscrubbers were $24.18, $18.37, $15.00, $6.00, $0.54, and $0.41 per broiler, respectively [25]. Capital costs should regard pretreatment of gas (often by spray systems), concentrations of odor-causing compounds, air quantity to be treated, removal efficiencies, additional duct work, available space, degree of automation, degree of flexibility and specific design features, while operating costs will likely include electricity, media replacement, inspection, and general maintenance [27]. Boyette [27] notes capital costs range from $10 to $40 per cfm for systems treating less than 15,000 cfm of exhaust gas, while annual operating costs can be between $2 and $14 per cfm. Further research in biofilter design may further reduce costs and provide an economically feasible remedial activity to diminish odor problems from typical broiler operations.

Ionization

Dust has been implicated in transport and magnification of odors from livestock facilities, as odorants can absorb to particle surfaces [1, 5, 6, 7]. Ionization of air imparts a negative charge on dust particles that can then be attracted to collection plates or rods. Negative ionizer bars (50 cm long; 20 in) operated at 20 kV were tested in a poultry house by Gast et al. [28]. Ionization reduced dust concentrations by about 78%, with reductions ranging from approximately 68 to 92% for 6 different ranges. An electrostatic space charge system was shown to remove up to 91% of artificially generated dust and 52% of dust generated by mature White Leghorn chickens in a caged layer room [29].

An apparatus consisting of 2 negatively charged needles located 0.25 m (0.8 ft) above the floor and a positively charged aluminum collector plate (0.76 m high by 1.4 m long; 2.5 by 4.5 ft) located in front of the door, charged at 12 and 8 kV, respectively, was tested at a livestock facility [30]. Ionization was approximately 6 times greater at dust removal than gravity alone. Relative humidity had no apparent impact on reductions in dust concentrations.

An additional benefit of air ionization methodologies is reduced bacterial agents within a flock. Whereas 90% of chicks tested positive for

Salmonella enteritidis in an untreated facility, negative air ionizers reduced levels by 50% [26]. Similarly, Holt et al. [31] found a 97% reduction in *S. enteritidis* over a 6-d period using an ionization system. These findings may further influence the decision-making process for odor abatement selection, as the value of pathogen reduction may justify a more intensive remedial activity than would otherwise be considered.

Oxidants

Air cleaning of odor causing compounds by oxidation has been used for decades, using oxidizing agents, such as ozone, potassium permanganate, chlorine, and chlorine peroxide [32]. Ozone (O_3), a highly reactive form of oxygen formed by electrical discharge or interactions with ultraviolet light, has received the most attention of these chemicals due to its strong behavior and rapid decomposition [33]. Human health concerns exist for elevated ozone level exposures [34, 35], which Occupational Safety and Health Administration has addressed by setting permissible exposure limits at 0.1 ppm for an 8-h time-weighted average exposure.

Despite these apprehensions, research on ozone to remove odors from livestock buildings is currently underway in North Carolina [7, 36]. Evaluation of an indoor ozone system for odor and dust control effectiveness found total dust concentrations decreased by 60% and ammonia levels declined by 58% at the fan exhaust under maximum tunnel ventilation, compared with a nearby building without any ozone treatment (i.e., control).

Gas chromatography analysis suggests ozone breaks down the highly odorous organic molecule indole [37]. Similarly, Okuna [38] detailed the reactions of ozone with a number of odorants and found that amines, ammonical compounds, lower alphatic acidic compounds, sulfurous compounds, olefin-paraffin hydrocarbons, and others could potentially be reduced based on the mechanisms considered.

Hill and Barth [32] investigated the removal of ammonia and methylamine under laboratory conditions and established ammonia concentrations were reduced approximately 5-fold after a 1-h exposure (applying 2 times the stoichiometric ozone quantity). Methylamine similarly was decreased by 5 times its initial concentration upon similar exposure rates, but a 2-h contact time was required. The authors suggest the difference in contact time was due to the chemical structure of methylamine (i.e., the methyl group sterically hinders ozone from attacking the amine group). Both gases were reduced using lower ozone concentrations if longer exposure to ozone was allowed.

Windbreaks

A literature review of windbreak use in agricultural activities revealed sufficient information on traditional uses of such barriers (e.g., reducing soil erosion, wind and snow control, providing shelter) but exposed a lack of research on the use of such structures for odor control. Although the opportunity for additional study of natural and artificial windbreaks exists, information collected on the influence of height, spacing, and porosity on changes in wind direction and magnitude can be used to speculate on the potential for this odor-control method around poultry facilities. In addition, windbreaks may alleviate odor complaints, as human perception of nuisance odors is often influenced by visual images.

Early research showed windbreaks typically reduce the velocity of a 32 km/h (20 mile/h) wind for a distance 30 times the barrier's height [39]. A follow-up study came to a similar conclusion on windbreak effective distance [40]. Moysey and McPherson [41] later demonstrated a porosity of 25% offers the most effective wind reduction, with a range of 15 to 35% providing better shelter than a solid barrier. Borelli et al. [40] produced an updated model to better incorporate wind properties into the design of windbreaks.

Two hundred operations in Taiwan have constructed walls downwind of tunnel-ventilated poultry buildings and have seen reduced dust and odor emissions off-site [22]. Bottcher et al. [42, 43] examined the use of artificial windbreaks to redirect airborne dust particles exiting livestock facilities under the presumption odors are adsorbed and transported by dust, and increased turbulence downwind of the windbreak may have implications for dispersion from building fans. The effectiveness of module walls constructed of 3 × 3 m (9 × 9 ft) pipe frames covered securely with tarpaulins was determined by collecting aerial dust particles and demonstrating airflow from exhaust fans using smoke. An increase in the vertical height of the smoke plume subsequent to reaching the windbreak demonstrated the potential for reduced odors and dust concentrations downwind of animal facilities. Elbows placed on exhaust fans designed to redirect fan airflow upward provide some plume rise; however, dispersion models indicate tall stacks may offer further effectiveness [43].

Dependence on windbreaks as an odor reducing mechanism should be conducted cautiously as these structures enhance dispersion but fail to reduce odorous pollutant emission rates [42]. Nevertheless, windbreaks placed downwind of exhaust fans and litter storage areas may provide an economical management practice for broiler producers when used in conjunction with other air-cleaning practices. Artificial walls can be erected at minimal cost using a variety of materials, including metal, plastic, and wood, while natural windbreaks consisting of trees add aesthetic value in addition to controlling odors. Additional experimentation in placement and design may provide a low-maintenance odor reduction device.

INNOVATIVE MANAGEMENT SYSTEMS

A number of innovative technologies have been explored to control odors from poultry and livestock operations. Many of the alternative management systems require further study; however, some may provide effective options to broiler producers for odor, ammonia, and dust control.

Amendments and Proprietary Treatments

A variety of manure amendments have been used to reduce odor and ammonia volatilization. A number of commercial products are available on the market that may aid in odor reduction from broiler houses. Additions follow 4 main principles: 1) specific bacteria to promote orderly decomposition, 2) oxidizing and inhibiting substances to reduce decomposition, 3) enzymes or other biochemical moderating material, and 4) absorptive agents to retain volatile materials. Forty-four proprietary masking agents, deodorants, and digestive deodorants were tested on poultry waste in both laboratory and field settings [44]. It was generally found masking agents were the most effective, deodorants were moderately effective, and digestive deodorants were the least effective in reducing odors.

Ammonia emissions have been significantly reduced in broiler houses following the application of sodium bisulfate ($NaHSO_4$). Applied extensively in the form of the proprietary product Poultry Litter Treatment (PLT) [45], this acidic compound has been hypothesized to reduce atmospheric ammonia concentrations by direct chemical interactions with uric acid, lowered litter pH, and diminished ammonia generating bacterial populations [46]. The reduction in pH promotes the conversion of free ammonium ions to ammonium sulfate, while the excess sodium reacts to form sodium phosphate [47].

Although one study observed no influence on ammonia volatilization rates following sodium bisulfate [48], McWard and Taylor [49] found significant emission reductions over a 2-mo period. Pope and Cherry [50] applied PLT on top of litter in a brooding house according to the recommended rate of 2.27 kg (5 lb)/9.29 m^2 (100 ft^2) and reported pH readings 85% lower immediately after treatment compared with a control. These levels rose throughout the study but remained below pH 7, the level at which significant ammonia begins to be released [51]. Correspondingly, ammonia emissions were suppressed by 90% after amendment application and by about 50% after 2 wk. A similar study found ammonia concentrations 64% lower following a 48-d period compared with no treatment [47]. Furthermore, lesions were significantly reduced, while BW and lung:body weight ratios were greater for birds raised on treated litter. Sodium bisulfate was also found to reduce the frequency and populations of *Campylobacter* [52], suggesting further use as a pathogen control. Terzich [53] found similar findings following amendments of broiler litter with sodium bisulfate for ammonia, litter pH, pathogens and bird performance; a further benefit discovered included significant population decreases in the darkling beetle, a common poultry house pest.

Alum presents another granular poultry litter amendment receiving attention. A laboratory study was conducted on poultry litter using the chemical amendments $Al_2(SO_4)_3 \cdot 18H_2O$ (alum),

$Ca(OH)_2$ (calcium hydroxide), alum + $Ca(OH)_2$, and $FeSO_4 \cdot 7H_2O$ (ferrous sulfate). Alum was found to reduce ammonia volatilization by up to 99% compared with controls. The $Ca(OH)_2$ treatment yielded no significant difference than the controls, although the alum + $Ca(OH)_2$ mix did reduce ammonia losses by 57% (at a 2:1 ratio) [48]. A follow-up study [54] investigated the use of alum, ferric chloride, ferrous sulfate, and phosphoric acid on broiler litter. Each of these treatments resulted in a decrease in ammonia loss, but again alum was judged the best option, as ferric chloride is not cost effective, ferrous sulfate displays toxicity, and phosphoric acid contributes to phosphorus problems associated with land application. McWard and Taylor [49] found similar ammonia reduction results when testing both alum and sodium bisulfate. Researchers also suggest treatment of broiler litter with alum prior to drying for laboratory analysis [55]. This technique helps limit ammonia volatilization during sample handling to provide a more accurate measure of nitrogen (N), which can aid producers in litter application decisions. An additional benefit to alum applications includes reduced pathogen populations under typical amendment scenarios [52].

Both sodium bisulfate (i.e., PLT) and alum provide an effective remedial technique for reducing ammonia concentrations in broiler houses with additional benefits to bird production. The value of these amendments is furthered by their dry consistency, which presents a convenient form for hand or mechanical application; this allows producers to treat broiler houses themselves, juxtaposed to liquid amendments that require specialized spray systems typically applied by private firms. An economic analysis found that these 2 treatments ranged in price from \$220 to \$460 per ton, resulting in a cost of \$11 to \$16 for 92.9 m^2 (1,000 ft^2) at recommended application rates [49]. Another cost-benefit analysis showed that ammonia reduction by ventilation during cold periods would cost \$3,800 per flock (19,000 birds weighing 4 lb each) vs. \$400 for alum if 2 tons were applied [54].

Minerals, such as zeolite, have also been shown to be effective at reducing ammonia volatilization. Addition of a natural zeolite (38% weight) to poultry manure during composting yielded a 44% reduction in ammonia loss [56]. Higher N values in the final product increased the value of the composted material as a fertilizer. Acidified clays (36 and 46% acid) yielded similar reductions in ammonia emissions to sodium bisulfate and alum and resulted in reduced darkling beetle counts, improved feed conversion, and better carcass quality [49]. Nakaue et al. [57] found that a zeolite treatment with clinoptilolite was more effective at reducing ammonia after 28 d, suggesting applications at earlier stages resulted in the amendment sifting into the shavings, reducing efficacy. If used as the sole source of litter clinoptilolite resulted in elevated dust concentrations that contributed to increased mortality. Clinoptilolite resulted in no significant reduction in odor concentrations or emission rates compared with an untreated control [58].

Kithome et al. [56] also investigated the use of coir (mesocarp of coconut fruit) as an amendment to poultry manure during composting. Addition of 33% coir produced a 49% reduction in ammonia losses, acting as an ammonia adsorbent. This amendment out-performed the other treatments, which included 2 natural zeolites, clay, $CaCl_2$, $CaSO_4$, $MgCl_2$, $MgSO_4$, and alum. However, the required amendment application rates may present this as a poor economic alternative. Yucca saponin, an extract from the yucca plant, has been tested with conflicting results. Johnston et al. [59] found no significant decrease in ammonia concentrations. On the contrary, Amon et al. [58] found the yucca product De-Odorase [60] reduced mean ammonia levels in a treated room by 38% and the total mass of ammonia emitted by 50%; however, significant decreases in odor concentrations or odor emission rates were not found.

Zhu et al. [61] tested the effect of 5 commercial products on volatile fatty acids, total volatile solids, and other odorous constituents inherent to manure. All 5 additives reduced odor threshold levels by 58 to 87% compared with the control. Three of the additives demonstrated reductions in volatile fatty acids and total volatile solids concentrations. These results led to the conclusion that odors are not directly associated with the amount of total volatile fatty acids but rather with specific compounds. The authors suggest that future research should focus on the specific fatty acids responsible for foul odors.

Products composed of sodium silicate and ethylene glycol and Ca and Fe silicates with a phosphoric acid coating have also been marketed. Moore et al. [62] found the sodium silicate and ethylene glycol product to increase, rather than decrease, ammonia volatilization rates from poultry litter. No influence in ammonia volatilization rates were observed following the addition of the Ca and Fe silicate with a phosphoric acid coating product to poultry litter [48]. An earlier study found that phosphoric acid and superphosphate (calcium phosphate; $Ca(PO_4)_2$) did lead to diminished ammonia generation, but both were found ineffective after 17 d [63]. Hydrochloric acid (HCl) and sulfuric acid (H_2SO_4) were applied to broiler litter and were successful at lowering pH for extended periods. Safety issues are a concern in using these strong acids, but bird mortality decreased significantly and a net increase in profit of $5,000 was obtained for 1 batch at a cost of $150 per house for HCl [64].

Fly ash from coal combustion mixed with organic wastes has also been shown to reduce odor emissions [65]. This amendment provides a dual purpose, acting as an odor abatement technique while concurrently providing a disposal method for the fly ash by-product. A number of reviews have been written on the use of fly ash amendments (e.g., [66]). The use of polyacrylamides for odor control presents an evolving field in odor abatement technology [67] that may provide a management option for broiler operations.

Selection of litter amendments likely will receive continued emphasis to reduce ammonia and odor emissions from broiler facilities. Such amendments may prove cost-effective if an operation encounters high fuel prices, persistent disease occurrence, increased bird density, prolonged ammonia-related stress, and required management situations [68].

Dust Suppression with Oil and Cover Materials

Oil (and fat) applications have been used to reduce dust concentrations by livestock industries in the Midwest and Canada. A variety of vegetable oils, including canola, corn, sunflower, flax, soybean, and rapeseed oils, along with mineral oils, have been used to control dust and odor from feed sources and building floors.

The primary focus of this technique has been to limit emissions from feeds, as this has been identified as the primary dust source in rearing facilities [6, 69]. Soybean oil reduced dust counts by as much as 99% following 0.5, 1.0, and 2.0% additions to dry feed [70]. Amendments have been shown to increase swine production and reduce respiratory illness; although broiler health impacts need to be examined, this practice may be a simple method to suppress dust. Additional measures, such as enclosing feed delivery and minimizing feed waste, may also reduce airborne dust concentrations.

Recent research has investigated oil suppression to limit dust originating from floors and bedding in animal buildings [71, 72, 73, 74]. This technique may provide a simple, cost-effective management practice to limit dust and associated odors from broiler facilities. Although oil sprayed on birds is not recommended, and application would be an incompatible practice with broiler rearing due to high bird density, oil sprinkling may still hold promise as an effective dust control technique. Broiler house activities, such as removal of grow-out and during cake-out and clean-out practices, contribute to odor complaints; therefore, oil may be applied to litter immediately after flock removal and before cake-out. Additional oil could also be applied to stored litter. These practices would be a low labor-intensive method as well as a cost-effective technique because vegetable oils typically cost $2/gal [75]. Best engineering judgment on application rates would be needed at present, but further research could examine the transferability of this innovative technology to broiler operations.

A variety of cover materials have also been evaluated to control odors from livestock manure. Materials used have included chopped cornstalks, sawdust, wood shavings, rice hulls, ground corncobs, and grass clippings, all as separate amendments and as a mixture with oil (both waste oil and vegetable oil) [76]. Grass mixed with oil was found to effectively reduce odors by almost 50% based on human panel scores, with corn cobs and stalks also showing marked reductions. Xue et al. [77] found that wheat straw covers suppressed both ammonia and hydrogen sulfide emissions by 95% in laboratory and pilot tests. Rubber and geotextile membranes may also act as an odor barrier and provide a growth substrate for microorganisms that break down odorous compounds [78].

These studies show that a variety of materials can be used as covers to reduce odor emissions from agricultural operations. Although these techniques have been tested on livestock waste, information may be inferred from this research that could be applicable to covers for broiler litter and mortality compost piles. Further investigation may yield a rapid, economical use for both natural and artificial materials in reducing odors from litter systems.

CONCLUSIONS AND APPLICATIONS

1. Data on odor abatement methodologies applied to broiler operations remain limited in published literature. Both traditional and innovative techniques require rigorous investigation to increase efficiency, decrease costs, and protect human and broiler health. Transferability of technologies used in other odor generation industries should be examined to prevent conducting redundant research in areas that have already been considered.
2. Traditional abatement technologies remain a potentially effective management option to reduce atmospheric emissions. Scrubbers, filters, ionization techniques, and oxidation have all been found to reduce odors, dust, and ammonia concentrations. Variations on these established systems include less expensive mist systems and biofilters that utilize microbial activity to convert odorous compounds to more benign forms.
3. Natural windbreaks provide an entrapment mechanism for odorous compounds that require minimal maintenance. These structures also provide a visual barrier that may reduce the perceived odor production of broiler operations.
4. Innovative technologies have been increasingly investigated to explore efficient, cost-effective alternative management systems. Litter amendments can reduce odor and ammonia emissions significantly. Acidic salts, zeolite, and other chemicals have shown varying degrees of success. Oil applications to litter may prove to be a simple, inexpensive method to reduce dust concentrations and odor. The transfer of this technology to broiler operations may have the potential to reduce odor release during clean-out activities and litter storage.

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