PARTICULATE MATTER EMISSIONS FROM CONFINED ANIMAL FEEDING OPERATIONS: MANAGEMENT AND CONTROL MEASURES

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Objectives

- ❑ Summarize the state of knowledge concerning the sources, emissions and control of particulate matter from Confined Animal Feeding Operations (CAFOs).
- ❑ Guide producers in the selection of appropriate facility designs, manure handling and other approaches to mitigate the effects of particulate matter emissions from CAFOs.
- ❑ Identify key gaps in the research base concerning PM emissions from CAFOs.

Introduction

Particulate matter (PM) is among the most prominent air pollutants associated with confined animal production. In general, PM consists of solid- or liquid-phase particles whose settling velocity in air is too small to overcome the changing aerodynamic forces exerted upon them by normal air currents. Particles may be emitted directly by a source (e.g., hoof action on uncompacted, dry manure), or they may be formed in the atmosphere (known as secondary PM) as a result of chemical reactions involving one or more precursor gases, including ammonia (NH_3). Once emitted or resuspended into the air, PM may eventually settle out or be intercepted by obstructions or surfaces, but its general tendency is to remain suspended in air well beyond what its trajectory would be in a vacuum. Health-based standards for airborne PM exist for both occupational and ambient conditions.

Control Techniques

Control of PM from CAFOs depends on the housing configuration (open lot vs. enclosed) and the type of PM being considered (primary vs. secondary PM). For open-lot CAFOs, increasing the frequency with which manure is harvested will control PM emissions by reducing the depth of dry, uncompacted manure subject to hoof action. PM emissions can be controlled to an arbitrary extent by the application of supplemental moisture via solid-set sprinklers, towed “big gun” sprinklers or water trucks; the extent of control is related to the frequency and depth of water application. Frequent manure harvesting to minimize the depth of dry, loose manure will increase the effectiveness of supplemental water applied for dust control. Increasing the stocking density (number of animals per unit area) increases the moisture excreted per unit area of open-lot surface, but this strategy appears to control PM emissions only modestly in semi-arid regions and may give rise to unacceptable feed-to-gain performance losses associated with increased agonistic behavior. Surface mulches, modified feeding schedules and topical application of salts and resins are all experimental control methods. For livestock and poultry produced under roof, PM emissions may be controlled by misting with water or various oils (e.g., soybean oil). For swine production over slatted floors, increased stocking density will reduce PM emissions by increasing the hoof action that pushes manure accumulations into the pits or flush gutters below rather than leaving it on the surface to dry and to be resuspended. The length and orientation of feed delivery tubes may be adjusted to reduce PM emissions from feed boxes. To the extent that secondary PM results from CAFO ammonia emissions, the control of ammonia emissions will help to reduce the stoichiometric potential for fine-particle formation. Ammonia emissions are covered in more detail in a companion paper (Arogo et al., 2001). Emissions of PM from unpaved roads can be controlled by consistent application of supplemental water or holding pond effluent, by periodic application of petroleum-based resins, or by restricting vehicle ground speed.

Major Research Gaps

1. Open-lot CAFOs

PM emissions from open-lot CAFOs have received limited research attention but are becoming a higher priority in semi-arid regions of the United States. Most of the research thus far has focused on the use of supplemental moisture to increase manure compaction and reduce dust potential. Other approaches require greater attention, particularly in regions where supplemental water is scarce. Emission factors for PM from open lots are variable and inaccurate, and dispersion models for ground-level area sources need to be improved.

❑ Document and/or refine NH_3 emissions estimates from open lots in relation to feed composition, stocking rate and regional/seasonal hydrology.

❑ Using direct, physically based methods, generate new emission factors for open-lot PM that are not artifacts of Gaussian or other empirical dispersion models.

❑ Quantify the emissions reductions and normalized costs of open-lot abatement measures such as increased stocking density, active water application, mulches and manure harvesting practices.

❑ Quantify the effect of source-boundary controls such as vegetative barriers and “water curtains” on downwind PM concentrations.

❑ Determine the influence of diurnal moisture applications and other control measures on the profile, viability and persistence of bioaerosols in open-lot PM emissions.

2. Livestock and poultry housing

Much more data need to be taken on emission rates in order to better determine both mean emission rates and variability of emission rates due to various environmental and management factors. Such factors as litter moisture, feed characteristics and lighting management all have effects on dust generation, and it will require a number of studies in order to confidently recommend management procedures to improve dust emissions. Dust control technologies need further analysis. While air ionization is promising, much work needs to be done in order to see if this technology can be applied economically, reliably, and safely. Other dust reduction technologies are also in their infancy and need to be developed further in order to test their economic and environmental viability.

3. Secondary fine particles (ammonium salts)

Research should address standard methodology to adequately quantify ammonia emissions, particularly in open housing and various climates and climatic conditions that promote the formation of PM. Once emissions can be quantified in a reasonably reliable fashion, then it is possible to evaluate management practices thought to reduce emissions. Research must address multi-media impacts of all manure collection, handling, treatment, storage and utilization options commonly employed by livestock producers.

In short, little is known about the direct impact of CAFO-derived ammonia on regional enrichment of fine PM. Research needs in this regard are fundamental.

❑ Quantify the contribution of CAFO-derived ammonia to regional or airshed-scale enrichment of fine PM.

❑ Validate dispersion models that incorporate algorithms for formation of secondary PM from volume and area sources of ammonia gas.

4. Monitoring and dispersion modeling

- ❑ Develop and validate dispersion models that account for differential settling velocities across the full distribution of particle sizes in CAFO-derived PM.
- ❑ Improve and validate deposition algorithms for CAFO-derived PM.
- ❑ Impress upon the research community the critical need to provide averaging times along with monitoring and/or sampling data.
- ❑ Improve the design of size-fractionating ambient PM samplers for applications to agricultural PM.

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