Ohio State University Extension
Environmental Management Program

Minimizing NH_3 Emission from Manure Application

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Overview

- The global abundance of N fertilizer has dramatically increased agricultural productivity.
  - The synthesis of NH_3 and other N fertilizers has improved the diet and living conditions for billions of people.
- N loss to the atmosphere as ammonia (NH_3) gas can cause undesirable effects impacting air quality, ecosystem productivity, and human health.
  - Dramatic increases in atmospheric ammonia emissions have been reported in recent years in areas of intensive animal agriculture.
- Animal production is reported to be the largest source of man-made NH_3 emission in North America.
  - The U.S. Environmental Protection Agency (EPA) estimates that animal agriculture accounts for 50 to 85 percent of total man-made ammonia losses in the United States (Battye et al, 1994).

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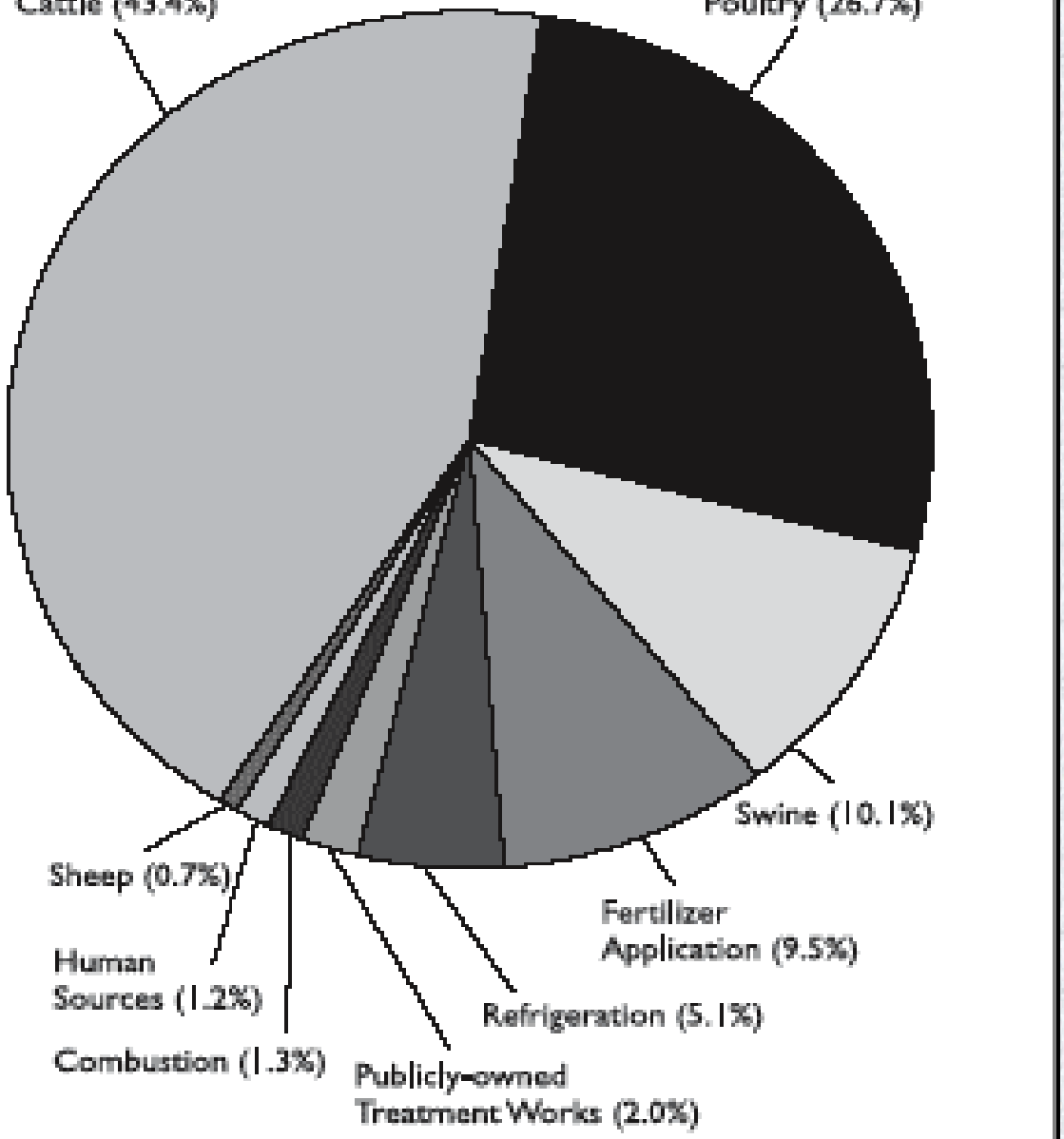

Figure 2. Estimates of ammonia emissions from man-made sources in the U.S. in 1994 (Battye et al., 1994).

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NH_3 losses

- Across all animal sectors 50 to 63% of the excreted NH_4-N is lost from animal housing, manure storage or manure application.
  - Of these losses, typically 40 to 50% occurs in housing, 5 to 15% from storage, and 40 to 55% manure application.
  - Improved manure and fertilizer management practices will reduce volatile losses of this valuable resource.
    - Commercial fertilizers such as UAN 28% and 32% (Urea-ammonium nitrate), anhydrous ammonia

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Whole-farm/holistic approach

- It is important to consider NH_3 loss from a whole-farm & ecosystem perspective.
  - NH_3 conserved in barns may later be lost during manure application.
  - Conserve NH_3 during manure application will only conserve the fraction that has not already been lost from barns and storage.
- Potential air quality vs water quality trade-offs.

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Management strategies

- Housing ventilation systems may be equipped to remove ammonia using physical, chemical or biological mechanisms.
- Covering manure storage facilities can result in substantial reductions of ammonia volatilization.
- One of the most effective methods is the sub-surface application of manure, which significantly reduces ammonia losses compared to surface broadcasting of manure.

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Manure application

- NH_3-N that is lost to the atmosphere is not available for crop utilization.
- Injecting liquid manure into the soil or incorporating it with tillage are the most effective ways to reduce NH_3 losses
  - most tillage and injection tools are not compatible with no-till cropping.
    - Water quality vs air quality

Factors affecting NH_3 loss during application

- Climate
- Soil Properties
- Manure Properties

Weather conditions

- Ammonia emissions are highest under warm, dry, windy conditions (i.e., when evapo-transpiration rates are high).
  - Ammonia loss is generally greater as dry matter and viscosity increase because of delayed infiltration.
  - Ammonia emissions increase with an increase in temperature and wind speed
    - Decrease with an increase in relative humidity.

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Weather conditions

- Ammonia emissions tend to be lower in cool and wet conditions and after light rain
  - Available water holding capacity of soils can make spreading conditions unfavourable, increase soil compaction and reduce infiltration of liquid manure.
  - Timing of application close to rainfall can also reduce ammonia emissions (Genermont and Cellier, 1997; Misselbrook et al., 2005; Reidy and Menzi, 2007; Søgaard et al., 2002; Sommer and Olesen, 2000).
    - Air quality vs water quality concerns
    - Ability to predict rainfall quantity, duration, intensity, etc…

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Daily variation in ammonia emissions

- Ammonia emissions tend to be lower at night due to reduced air movement (windspeed), cooler temperatures and higher humidity.
  - Applications between evening and early morning have been shown to reduce emissions by up to 50% compared with spreading during the middle of the day (Moal et al., 1995; Sommer and Olesen, 2000).

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Seasonal variation in ammonia emissions

- Seasonal variations lead to largest ammonia emissions in warm summer conditions and lower emissions in cool, moist, but not frozen, winter conditions.
- Emission reductions based on seasonal management of manure application has been shown to potentially reduce emissions by 20% compared with previous normal practices (Moal et al., 1995; Reidy and Menzi, 2007).
  - Targeted seasonal management of solid and liquid manure application has the potential to reduce overall annual ammonia emissions.

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Soil properties

- When manure slurries infiltrate into the soil, the potential for volatilization decreases.
  - Sandy soils with high infiltration rates commonly have less NH_3 loss than from manure applied to finer-textured soils.
- Saturated soils, compacted soils, and high-pH soils are more susceptible to NH_3 losses

Manure properties

- The dry matter content of the animal manure influences NH_3 loss.
  - Manure with low solids content tend to infiltrate more quickly and have less NH_3 loss than high dry-matter materials that remain on the surface for a longer time.

Manure properties

- Liquid manures have a very high initial NH_3 loss rate after application.
  - Abatement measures such as incorporation, must be done immediately after application.
- Ammonia loss rates from solid manures are slower.
  - More time is available to perform abatement measures such as incorporation.

Manure properties

- Manure that sticks to vegetation when applied will tend to have greater volatile loss than manure that makes direct contact with the soil.
  - Surface banding the manure is a lower-cost method of minimizing contact with vegetation and taking advantage of the protective effect of vegetation or crop stubble.

NH_3 reduction strategies

- Manure separators produce a liquid and solid material that allow more precise nutrient management and may also reduce the hauling costs.
  - Separation at point of excretion more successful (as much as 80 percent reduction)
  - Liquid fraction generally infiltrates more quickly than the more solid manures.
- Soil tillage before application can improve infiltration rate and reduce NH_3 loss.
  - Cultivation after application reduces NH_3 loss by burying the majority of the manure.
- Soil incorporation should be done immediately after application for liquid manure, but may be delayed slightly for solid manures.
  - A one-pass system for application and incorporation is preferred when applying liquid manures.
  - Injecting animal manure beneath the soil surface is very effective for minimizing NH_3 emissions.

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Summary

- Growing attention is focused on environmental impacts of NH_3 emissions.
- NH_3 loss not only presents a potential environmental problem, but the loss of a nutrient that could be conserved for beneficial plant nutrition.
- Agricultural emissions of NH_3 are primarily associated with animal production.
- Management practices are available to effectively manage animal manures to maximize the nutrient benefits.
- Increasing demand/cost of fossil fuels, i.e. fertilizer, will be a significant driver for nutrient conservation measures.
  - i.e. economic incentives to minimize nutrient losses.