UMassAmherst Outreach UMass Extension

Conserving Ammonia in Manure

Introduction:

Ammonia can amount to over ½ of the nitrogen available in manure.

Ammonia (NH_3) emitted from livestock manure is not only an odor concern; it represents financial losses through increased fertilizer cost, and is of environmental and human health concern. Ammonia in the atmosphere is a precursor to several greenhouse gases and forms particulate matter ($PM_{2.5}$) a possible health concern. Farmers in many European nations and Concentrated Animal Feeding Operations in the United States are required to follow ammonia mitigation practices. Over half of the nitrogen content of manure can be in the form of ammonia which is readily lost to volatilization under hot, aerated conditions. Proper management of animal diet, housing, manure storage and land application will maximize nitrogen retention for crop utilization with a reduction in air pollution. Weather conditions as well as the physical and chemical composition of the manure must also be considered when choosing an ammonia mitigation practice. Some management practices are more cost effective than others, for example; following environmental conditions as indicators for timing land application of manure has no additional infrastructure cost to the farmer, while installation of biofilters in housing facilities and acidification of manure can be very expensive.

Best Management Practices:

Up to 90% of the ammonia nitrogen in manure can be lost if not incorporated into the soil at the time of land application.

Different animal species, housing, manure storage and land application all affect management practices for mitigation of ammonia volatility. Poultry manure contains twice as much ammonia as dairy cattle manure. In order of greatest ammonia manure content to least is: chickens, pigs, dairy cows, and beef cows. Higher dry matter content increases the ammonia volatility potential of manure and up to 90% of the ammonia nitrogen content of manure can be lost at the time of land application. Figure 1 shows the 2005 US EPA estimates of average ammonia losses from different livestock operations:

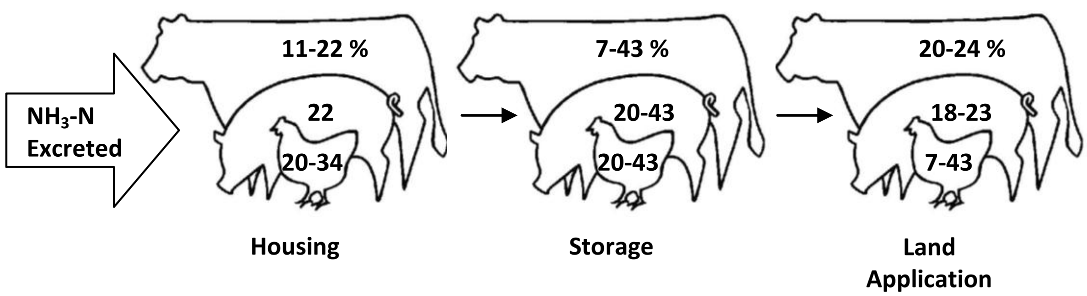

Figure 1. Percent NH_3 emissions from total manure-NH_3 in each component of livestock operation (EPA National Emissions Estimates, 2005)

Most ammonia volatilization occurs in the first 8-24 hrs after application to the field therefore incorporation should occur within several hours.

These estimates demonstrate the variance of ammonia losses among different animal species, types of livestock operations, and management practices. Sample manure for nutrient content prior to land application in order to supply proper nutrients for plant growth. In the Northeast, samples can be sent to the University of Maine Analytical Lab to be tested (http://anlab.umesci.maine.edu/soillab_files/forms/Manure.pdf) or the DairyOne lab (). To minimize total nitrogen losses, manage manure for reducing ammonia emissions as well as other forms of nitrogen such as nitrate which can be lost by leaching and other nutrients (P) in surface runoff.

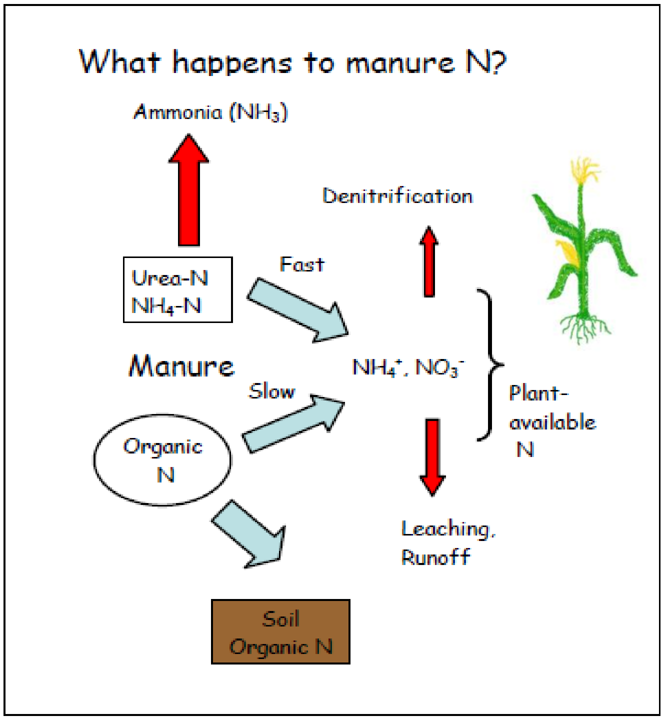

Figure 2. What happens to manure N? (Jokela and Meisinger, 2008).

Diet: Decreasing the intake of crude protein by livestock reduces total nitrogen excreted. Practicing phase feeding based on the growth stage of the animal can reduce ammonia in manure without compromising production of meat or milk. Dairy cows in particular have low nitrogen intake to milk protein ratios, meaning that only about 14–40% of consumed nitrogen is converted to milk protein and the rest is excreted in feces and urine.

Housing:

For the health and safety of the farmer and animals, ammonia concentrations in housing facilities should never exceed 25ppm. Ammonia levels can be tested fairly inexpensively with ammonia strips (http://www.microessentiallab.com/). Biofilters are one way of filtering ammonia out of ventilation air using an organic material such as wood chips. These filters can be expensive to install and require constant maintenance to ensure proper operation. They are typically installed in larger animal feeding operations to help keep animals (and farmers) from suffering lung damage due to ammonia-based $PM_{2.5}$ and to reduce atmospheric emissions. The use of porous flooring materials is not recommended because they trap and release ammonia into the housing facility. Frequently flushing housing facilities and storing manure with water will reduce the volatility but uses a large quantity of water. Providing adequate bedding material such as pine shavings, straw, or shredded newspaper and frequently cleaning pens is a simple way of reducing ammonia volatilization by trapping ammonia in the organic matter and creating a stable form of nitrogen for use by crops in the field.

Storage:

Permeable and impermeable covers are two options for containing ammonia during storage. Permeable covers made of chopped straw or other easily accessible organic material on the farm are a good option to cover manure tanks or lagoons, creating a biologically active zone where ammonia is decomposed by micro-organisms. These covers must be replaced or replenished occasionally due to weather conditions. Permeable covers are less effective at controlling emissions than impermeable covers, but they are more cost effective. Impermeable covers made of wood, fiberglass, or cement will reduce volatility during storage, are long lasting, and are capable of reducing ammonia emissions by 80-95 %. Filling large storage tanks from the bottom allows a manure crust to form which will also reduce ammonia loss.

Acidification of manure with additives such as phosphoric acid (H_3PO_4), hydrogen sulfide (H_2S), and sulfuric acid (H_2SO_4) will reduce volatility potential because the microbes that convert more complex forms of nitrogen to ammonia prefer a basic pH (>7). Increasing acidity of soil and manure is not always effective at reducing volatility, and has the potential of creating and releasing other pollutants besides ammonia. Planting a buffer strip of trees or tall grasses downwind and around housing and storage facilities can help control odor by capturing ammonia before leaving the farm.

Land Application:

Of the many methods for reducing ammonia volatility, management of land application can be the most cost effective and have the greatest impact for conserving nitrogen. The following manure application methods are listed in order of being most effective to least effective for reducing ammonia volatility: Tine injection, disc injection, immediate incorporation after surface application, band spreading with trailing hoses or trailing shoe without incorporation, broadcast application with incorporation. Broadcast application of slurry manure without incorporation should be avoided at all times because this method increases air to ammonia contact and allows time for all ammonia to be lost. In hayfields, pasture, or on no-till fields, manure must be applied without incorporation and is therefore more susceptible to ammonia loss. Special tillage implements for injecting manure can be expensive, may not be any more effective than immediate incorporation, and are only appropriate for non-rocky soils. Most ammonia volatility occurs in the first 8-24 hrs after application to a field therefore incorporation should occur within several hours. Without incorporation or the use of special tillage implements for injection, environmental indicators can be used to time the application of manure for retaining ammonia.

Environmental Conditions:

Environmental conditions such as cold temperature, low wind speed, and some rainfall are the best time for applying manure to fields. If possible, apply manure to growing crops or cover crop because the already established crop canopy and root system will help deter nitrate leaching and nutrient run off. The recommended time for application of manure to pastures is on cold, calm days in late fall or very early spring. Do not apply manure to frozen ground with a slope because this greatly increases the chances of nutrient runoff. Some rainfall can help manure infiltrate the soil; however, saturated conditions will increase runoff and leaching.

Soil conditions also affect ammonia volatility. The urease enzymes found in soil and feces creating ammonium from urea slow their activity below 50°F (10°C) and below a pH of 7. Soils with a high cation exchange capacity (CEC) are able to hold the negatively charged NH_4 ions in cold soils for later use by plants.

Best Conditions for Land Application of Manure:

1. Immediate incorporation or injection
2. High CEC and soil organic matter
3. pH of soil and manure below 7
4. Little or no wind
5. Cold temperatures but not frozen soils
6. Moist but not saturated soils
7. Apply to a growing crop

Conclusion:

Conserving ammonia nitrogen from manure has economic and environmental benefits. Applying manure to meet crop needs of 160 lb N/ac and 80 lb P_2O_5/ac has a nutrient value of about $110/acre if fertilizer N costs $.50/lb and P_2O_5 costs $.38/lb. These cost savings can be maximized if ammonia mitigation practices mentioned in this article are followed.

Resources:

Iowa State University. Air Management Practices Assessment Tool. 2006. <http://www.extension.iastate.edu/airquality >.

Jokela, W.E, and J.J. Meisinger. Ammonia emissions from field applied manure: management for environmental and economic benefit. *In* Proc. Wisconsin Fertilizer, Aglime & Pest Management Conference. 2008. 47: 199-208.

University of Maine Analytical Laboratory. Manure Analysis Form: http://anlab.umesci.maine.edu/soillab_files/forms/Manure.pdf

University of Nebraska. 'New Air Emissions EPCRA Rule for Livestock & Poultry: General Information on the Ruling' . <http://water.unl.edu/emissionsrule>.

For more information visit www.umass.edu/cdl

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This publication has been funded in part by Mass. Dept. of Agricultural Resources in a grant to the Massachusetts Farm Bureau Federation, Inc. by Mass. Dept. of Environmental Protection, s319 Program, USDA-SARE.