Ammonia Losses from Broadcast Liquid Manure

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Summary and Implications

Based on past research, we can estimate how much nitrogen (N) will be lost following land application of liquid manure. Losses can range from nearly zero to 100%, depending on a number of variables. As more is lost, the acreage needed for manure application is reduced, or plants lack adequate N for optimum growth. By being able to estimate how much N will be lost, we can fine-tune manure applications to optimize plant growth, economic returns, and minimize environmental risk.

Introduction

Ammonia volatilization from broadcast manure has been studied by numbers of researchers, both in the United States and abroad, for many years. The concern is that we need to know how much ammonia is lost following broadcasting manure, and leaving it on the soil surface, so we can apply the proper rates of nitrogen (N) for crop production. This paper reports on the results of those research projects.

Materials and Methods

A literature search was conducted. This paper summarizes a number of research projects as reported in scientific journals.

Results and Discussion

There are four main factors affecting N losses from broadcast manure: (1) the percentage of N that is in the ammonia form, (2) weather, (3) the surface to which the manure is applied, and (4) time.

We know from sampling how much of the N in manure is typically in the ammonia form. Ammonia forms ($NH_3 + NH_4^+$) normally make up from 40 to 70% of the total N content (7). Cabrera and Gordillo (2) summarized data from six other researchers and found that ammonia ranged from 38 to 78%. The N in stored manure is either organic N, or ammonia N; there typically is no nitrate N in manure. The ammonia is volatile; the organic N is not. Consequently the organic N is not lost during land application. Recent sampling projects by ISU ag engineers shows that the proportion of ammonia varies from a high of >80% of the total Kjeldahl nitrogen (TKN) in anaerobic lagoons; it is around 60 to 70% in slurry pits; and down to 10 to 20% of TKN in solid manure. The higher the solids content, the lower the ammonia percentage (Figure 1). In a swine slurry pit with 10% solids, we would expect the ammonia N to be about two-thirds of the total N. If the pit contains 75# of TKN per 1,000 gallons, 50# per 1,000 gallons would be ammonia.

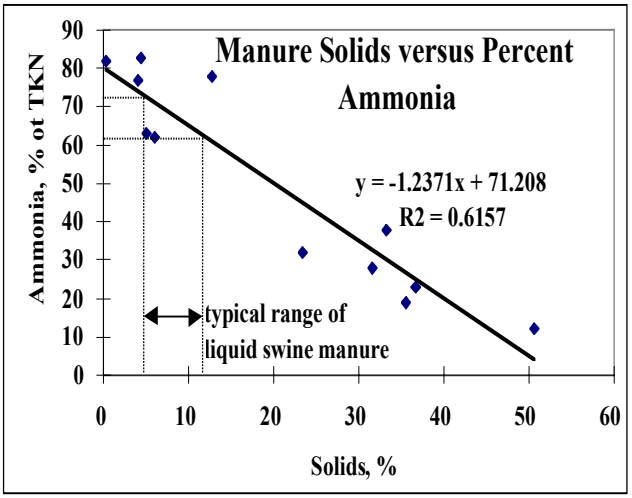

Figure 1. Percentage of solids versus ammonia as a percent of the TKN.

Studies have shown that ammonia loss is affected by temperature, humidity, and wind speed. As the climatic variables increase, ammonia losses occur faster. Bear and Royston (1) found that urine exposed to the air lost 92% of its N in 7 weeks at 38°C. At 32.5°C it took 12 weeks to lose that amount. Under warm, breezy conditions, much of the ammonia is lost in a matter of hours. Sommer et al. (6), and Lauer et al. (4), investigating losses from surface-applied liquid cattle manure found increasing loss rates with increasing temperature. Figure 2 summarizes losses under two different weather conditions. Nearly 80% of the ammonia was lost under warm conditions. Notice that the greatest loss occurs in the first 24 hours, more occurs the second 24 hours, and losses continue slowly after that. Remember that this is just the ammonia N; the organic N is not lost. For solid manure that starts out with 25% of the N in ammonia form, 25% is the maximum that will be lost. The organic N will remain.

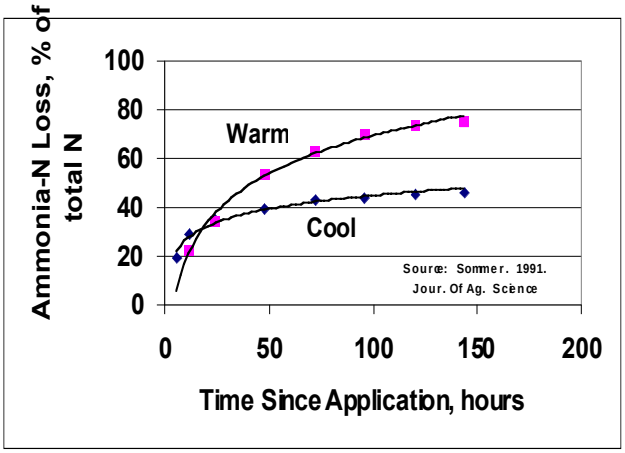

Figure 2. Affect of weather on ammonia losses.

The third factor affecting ammonia loss is the surface condition of the ground where the manure is applied. Losses are greater from crop residue than from tilled soil. The positively charged ammonium ion (NH_4^+) will attach to negatively charged particles. Iowa soils are generally negatively charged, so they will tie up the ammonium ions and reduce losses, compared with crop residue.

By combining the percentage of ammonia initially in the manure (Figure 1) with the losses from crop residue cover and soil cover, a chart of overall losses can be shown for normal weather conditions (Figure 3).

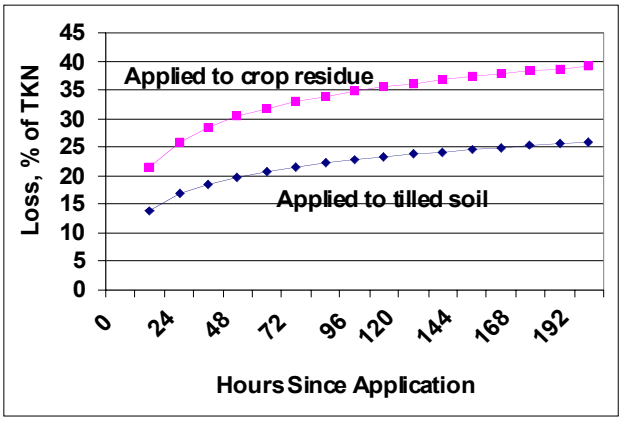

Figure 3. Ammonia nitrogen losses from broadcast manure during normal weather.

Time is one factor that can be controlled to some extent. Thompson (8)and Cabrera and Gordillo (7) reported that losses are usually high during the first 5 to 10 days. Losses from 11% to 78% (5) of applied have been reported. Lauer et al. (4) reported losses from 61% to as high as 99% of total ammoniacal N in 5 to 25 days and described three time-dependent stages. The first stage, when ammonia concentrations in the manure are high, had a half life of less than a day; at lower concentrations, ammonia had a 2 4-day half life; and the third, after much of the ammonia has been lost, had a half-life of 4 days or more. By reducing the time the manure is exposed, you can reduce losses. Losses only occur when manure is broadcast on the surface and left there. By injecting or incorporating manure immediately you can minimize ammonia losses. If manure must be left on the soil surface, Iowa estimates of N losses appear to be accurate.

References

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