DRAFT

Conversion of Reactive Nitrogen to N_2: The Role of Swine and Poultry Manure

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The bulk of the N fed to livestock ends up in manure, and in modern American Agricultural systems, where this manure is produced there is often a much greater supply than can be efficient or economically used as fertilizer on crops. For large animal feeding operations (AFO's) there is considerable expense associated with disposal of the manure. Various storage systems have been developed to deal with this excess manure, the most interesting of which, from the standpoint of integrated policy on N, convert the urea to N_2. These represent a choke point where reactive N is removed, on time scales of millennia, from biogeochemical cycles. The fraction of the feed N that is converted to N_2 or even can be converted to N_2 remain major unanswered scientific or technical questions; this brief report reviews the current state of knowledge.

The NRC (2003) report bemoaned the paucity of credible data on the effects of mitigation technology on rates and fates of air emissions from AFO's, but called for their immediate implementation. That report also called for a mass balance approach in which the losses of N species such as NH_3, NO, N_2, and N_2O are expressed as a fraction of the total N loss. Quoting from the NRC report:

Storage covers for slurry storage tanks, anaerobic lagoons, and earthen slurry pits are being studied as a method to decrease emissions from those containments. Both permeable and impermeable covers are being studied. Tested covers range from inexpensive material such as chopped straw (on slurry containments only) to more expensive materials such as high density polyethylene. Covers can decrease emissions from storage but their net effect on emissions from the system is conditional on how the effluent is used on the farm.

Anaerobic digestion in closed containment has been studied for many types of applications. Anaerobic digestion is the process that occurs in an anaerobic lagoon. When conducted in closed vessels, gaseous emissions including methane, carbon dioxide and small amounts of other gasses (possibly ammonia, hydrogen sulfide, and VOCs) are captured and can be burned for electricity generation, water heating, or simply flared. The in-ground digester being tested on a swine farm in North Carolina is an example of the ambient temperature version of this technology (there are also mesophilic and thermophilic designs). The concentration of ammonia remaining in effluent from that digester is higher than the concentration in lagoon effluent and can be volatilized once exposed to air.

Looking at recent articles, Shores et al. (2005), Bicudo et al. (2004) Funk et al (2004a), Funk et al (2004b) all reported a reduction in NH_3 emissions after a permeable cover was installed, but I have to get the full articles to find out the efficiency; these journals are not available at UMD electronically.   Miner et al. (2003) reported that a polyethylene cover can reduce NH_3 emissions by ~80%, but it is not clear what fraction of that N was converted to N_2. Harper et al. (2000) reported that in a well-managed swine lagoon denitrification N_2 losses can be equivalent to N lost as ammonia, in other words about 50% efficiency. Kermarrec et al. (1998) reported that sawdust litter helps reduce NH_3 emissions from pig manure with 44-74% of manure N converted to N_2, but > 10% of the manure N was released as N_2O. Sommer (1997) cattle and pig slurry tanks NH_3 3.3Kg N m^{-2} yr^{-1} until covered with straw then below detection limit. Mahimairaja et al. (1994) reported that NH_3 volatilization was reduced by 90-95% under anaerobic conditions.

Olivier et al. (1998) estimate the total 1990 NH_3 emissions from domesticated animals in the US at 1.4 Tg N yr^{-1} and the total from all land use and waste treatment at 2.6 Tg N yr^{-1}. NO and N_2O emissions from animals and land use are an order of magnitude smaller. Denterer and Crutzen (1994) estimated 30 Tg N yr^{-1} for total global NH_3 emissions with 22 Tg N yr^{-1} from domesticated animals; if the US is 6.5% of that (from Olivier et al) then this is 1.4 Tg N yr^{-1}. Dentener et al. (2006) estimate total global NH_3 emissions from all sources at 53 Tg N yr^{-1}. Smil (1999) estimated NH_3 emission plus denitrification at 26-60 Tg N yr^{-1}.

USD/NRCS (2001) estimate the total N excreted by livestock in the US as 9.6 Tg N yr^{-1}, with about half available to be reapplied as fertilizer.   Howarth et al. (2002) estimate 6 Tg N yr^{-1} excreted from livestock in the US and that roughly 1/3 is volatilized as ammonia, 1/3 leached and 1/3 denitrified.   The most Nr that could be removed through denitrification would be about 4 Tg N yr^{-1}; a realistic estimate of the amount of Nr that could be denitrified by coveing swine lagoons is half of the N excreted by pigs or about 5% of the total (0.5 Tg N yr^{-1}) Conclusion: enhanced denitrification in manure handling has the potential to reduce NH_3 emissions substantially, but the number cannot be quantified to better than a factor of two.

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