Management of Dairy Operations to Prevent Excessive Ammonia Emissions

S. Mukhtar, A. Mutlu, and S. Rahman
Texas A&M University System

Species: Dairy
Use Area: Animal Housing and Manure Storage
Technology Category: Management
Air Mitigated Pollutants: Ammonia

Description:

Dairy operations in the southwestern US are predominantly comprised of two management system; an open-lot system and a hybrid system of open-lots and free-stalls. In an open-lot dairy, cows are housed on un-paved corrals with access to feed bunkers and water tanks. Manure is scrapped, and process generated wastewater from milking parlor and rainfall induced lot runoff are stored in a retention control (lagoons and ponds) structure. In a hybrid system, lactating cows are fed and housed in paved free-stall barns and dry cows and heifers are kept and fed in un-paved corrals. In addition to scraping corral manure, manure from free-stalls is removed by flushing, scrapping or vacuuming. Flushed manure, wastewater from milking parlors and corral runoff are stored in retention control structures. Studies show that agricultural and animal feeding operations contribute considerable amount of ammonia (NH_3) to the atmosphere (Arogo et al., 2001; Anega et al., 2003). Cattle including dairy cows are the largest animal sources contributing to NH_3 emissions. Atmospheric NH_3 is considered to be a precursor to $PM_{2.5}$ (particulate matter with aerodynamic diameter less than 2.5 µm) (Anega et al., 2001; Gupta et al., 2003) and PM ($PM_{2.5}$ and PM_{10}) is one of the six criteria pollutants for which National Ambient Air Quality Standards (NAAQS) were developed by the USEPA.

Until recently, no comprehensive data was available on contribution of NH_3 emissions to the atmosphere from dairies in the mild southwestern climate of the US. The first step towards prevention of excessive emissions of NH_3 from southwestern dairy operations is to quantify them from different sources within a facility to assess how open-lot and hybrid dairy management systems, manure handling and storage practices and weather conditions impact NH_3 emissions. Once this information is available, specific on-farm practices may be explored and adopted to reduce excessive NH_3 emissions from "critical sites" within the operation.

Recently published (Mukhtar et al., 2008) and unpublished data from open-lot and free-stall dairies in Texas provided the following insight into NH_3 emissions from the ground level area sources of these dairies.

Open-lot Dairy (~2000 lactating cows)

- Total surface area of open-lot corrals = 103,000 m^2 (25.4 ac)
- Total surface area of primary (6,275 m^2) and secondary (46,094 m^2) lagoons = 52,370 m^2 (13 ac)
- Separated solids pile are = 500 m^2 (0.12 ac)
- Milking parlor crowding area = 500 m^2 (0.12 ac)

<u>Major Findings on NH_3 Emissions from Open-lot Dairy</u>
- Summer emissions were ~ 47% higher than winter emissions
- Lagoons contributed ~ 37 % to summer emissions and ~ 5% to winter emissions
- Corrals contributed ~ 63% to summer emission and ~95% to winter emissions
- Emissions from separated solids and milking parlor were negligible
- Emissions from open-lot corrals varied with cow density and resulting manure loading
- During summer feeding and shaded areas within an open-lot had significantly higher emission than the rest of the lot

Hybrid Dairy (~2000 lactating cows)
- Total surface area of open-lot corrals = 38,000 m^2 (9.4 ac)
- Total surface area of on-site compost windrows = 18,800 m^2 (4.6 ac)
- Total surface area of free-stalls **=** 10,000 m^2 (2.5 ac)
- Total surface area of primary (16,600 m^2) and secondary (16,500 m^2) lagoons = 33,100 m^2 (8.2 ac)
- Separated solids pile are = 110 m^2 (0.03 ac)
- Milking parlor crowding area = 925 m^2 (0.23 ac)

Major Findings on NH_3 Emissions from Hybrid Dairy

- Summer emissions were more than 50 % higher than winter emissions
- Lagoons contributed ~ 65 % to summer emissions and ~ 2% to winter emissions
- Free-stalls contributed ~ 36% to winter emissions and ~ 22% to summer emissions
- Corrals contributed ~ 11% to summer emission and ~ 26% to winter emissions
- Actively composting manure solids had significantly higher emissions than mature compost
- Feeding area within a free-stall contributed higher emission than bedding and watering areas

Mitigation Mechanism:

Reduction in NH_3 emissions from dairy waste as a result of reduced crude protein in dairy diets reducing urinary urea-N levels is well documented. Studies by Misselbrook et al. (2005) and others have shown reduced NH_3 emissions when manure from cows fed a reduced crude protein was applied to land. Ammonia volatilization rate from dairy manure and processes generated waste water exposed to the environment depends upon total ammonium concentration, pH, moisture content, air velocity, temperature etc. Mitigation technologies such as lowering poultry litter pH with alum to reduce NH_3 emissions from enclosed poultry housing has been shown to be effective (Moore et al., 2003). But dispirit housing systems (naturally ventilated facilities with much larger surface area compared to poultry barns) and manure management practices may render alum amendment to manure and wastewater to be impractical and in-effective. To date, an exhaustive search on existing or new technologies to reduce NH_3 emissions from the two southwestern US dairy production systems has resulted in no such information.

Applicability:

The management practices discussed in the Implementation section apply to mitigation of excessive NH_3 emitting from open-lot corrals, lagoons, and free-stall surface of dairy operations.

Limitations:

Lack of excess fresh or recycled water for frequent flushing, lack of extra storage capacity of retention control structures (RCS) to store additional flushed effluent, termination of on-site composting or moving the composting operation off-site etc. will be some of the limitations to implementing mitigation practices.

Cost:

No specific costs were estimated for implementing management practices. Costs range from minimal to substantial, depending upon the practice considered for reducing excessive NH_3 emissions. For example, doubling the frequency of flushing a free-stall will require pumping more fresh or recycled water and increasing the capacity of an existing RCS or building a new one adding much higher costs for implementing frequent flushing. Another substantial cost may be covering RCS to reduce NH_3 emissions. These RCS range in surface area from 2 to 5 or more hectares. Unless an economic incentive is provided, even partially covering these structures will be costly.

Implementation:

Data on NH_3 emissions measurements at the two southwestern dairy management systems; a free-stall and a hybrid system showed that following are the critical sites requiring implementation of practices to reduce excessive emission.

- Retention control structures (RCS include lagoons and ponds) during summer
- Feeding and shaded areas of open-lot corrals with higher cow density and manure loading
- Free-stalls
- Active compost windrows

Our findings suggest that during the summer season, management practices such as frequent removal of manure from critical sites of manure accumulation will be the key to reducing excessive NH_3 emissions from free-stall and hybrid dairies. These practices include frequent flushing of manure lanes, frequent scrapping of feeding and shaded areas of open-lot corrals, and possibly, moving the compost system off site. Land application of RCS effluent during cooler temperatures to avoid solar heating and where possible, incorporation or direct injection of effluent will prevent excessive loss of nitrogen and NH_3. Proper management of RCS is highly critical especially during summer season because these manure storage and treatment structures can contribute as much as two thirds of the total NH_3 emitted from dairy operations. Unfortunately, due to their large “foot print” covering or conversion of RCS to anaerobic digesters to reduce gaseous emissions to the atmosphere is very costly.

Technology Summary:

Ammonia emissions data from open-lot and hybrid (combination of free-stalls and open-lots) dairies in the milder climate of southwest US indicated that summer emissions from these facilities were nearly 50% higher than winter emissions. Due to their large surface areas, lagoons and open-lot corrals were the highest contributors of NH_3 emissions but little NH_3 was emitted from lagoons during the winter months. Within open-lot corrals and free-stalls, NH_3 emissions increased with greater manure loading and actively composting manure emitted considerable NH_3 even during winter months. While reduction in dietary N intake is known to reduce manure nitrogen content, no information on technologies to mitigate NH_3 emissions from these two types of dairy operations is available. Management practices such as frequent removal of manure from heavily loaded areas of open-lots and free-stalls, proper management of lagoons and other manure storage structures, summer irrigation of lagoon effluent during cooler temperatures, and where possible, incorporation or injection of effluent will help reduce excessive NH_3 emissions. While frequent scrapping of targeted open-lot corral areas can be achieved without substantial increase in costs, covering lagoons to reduce NH_3 emissions will be a very expensive mitigation practice.

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Point of Contact:

Saqib Mukhtar
Texas A&M University System
2117 TAMU
College Station, TX 77843-2117
USA
979-458-1019
mukhtar@tamu.edu
http://tammi.tamu.edu

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