Ammonia Control Best Management Practices

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There is growing interest in odor and gaseous emissions from livestock operations because of concern about global warming and enforcement of the Clean Air Act. This bulletin provides and evaluates best management practices for the control of ammonia lost to the air on dairy farms. Benefits are based on an approximation of ammonia emissions using currently available information. There are likely to be significant variations with region of the country, climate and management of the dairy cattle housing system.

Liquid manure storage and treatment

Synthetic cover

Impermeable lagoon cover with an air- and watertight seal over the manure surface. Requires a vent to release carbon dioxide and methane and a drain to pump the rainwater off. Cover concentrates nitrogen in the liquid in the lagoon. Manure samples should be taken to ensure that nitrogen is applied to crops at appropriate rates.

Benefits

Open lot system: Moderate reduction
Freestall scrape system: High
Freestall flush system: High

Geotextile cover

Permeable cover constructed of nonwoven synthetic felt. Constructed to provide complete coverage over liquid surface. Cover concentrates nitrogen in the lagoon. Manure samples should be taken to ensure that nitrogen is applied to crops at appropriate rates. Loss of evaporation from surface reduces storage capacity. Monitor lagoon liquid levels frequently and adjust land application plan if needed.

Benefits

Open lot: Moderate
Freestall scrape: Moderate
Freestall flush: Moderate

Solids separation

Gravity or mechanical separation system to remove manure solids from liquid waste stream. Separation pits should be cleaned on a regular basis. Holding times should be less than one month. Solids separated from mechanical

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systems should be removed from the separator on a regular basis, not to exceed three days.

Benefits

Open lot: Low
Freestall scrape: Low
Freestall flush: Low

Separate slurry and liquid manure basins

Construction and use of separate holding basins or lagoons to keep parlor wastewater and corral runoff away from concentrated slurry (manure and urine). Applicable systems include freestall scrape and open-lot dairies, which scrape their feeding alleys.

Benefits

Open lot: Low
Freestall scrape: Moderate
Freestall flush: No benefit

Aerated lagoon

Biological treatment basin designed to decompose liquid manure and nitrify ammonia in the presence of oxygen. Systems should utilize submerged microbubble systems to reduce ammonia loss. Operational cost for lagoon aeration can be significant.

Benefits

Open lot: Moderate
Freestall scrape: Moderate
Freestall flush: High

General practices

Vegetative or wooded buffers

Mixture of hardwood and evergreen trees or shrubs control, capture and mix higher, elevated, cleaner air with lower, dust- and odor-laden air from the ground surface. Buffers are also effective on odor and dust. Should be installed between production facility or lagoon and neighbors. (An established stand has reached its mature growth stage; establishment refers to sites that have not reached mature growth.)

Benefits

Established
Open lot: Moderate
Freestall scrape: Moderate
Freestall flush: Moderate
Establishment
Open lot: Low
Freestall scrape: Low
Freestall flush: Low

Freestall barns

Scrape built-up manure

Removal of built-up manure around the yard and manure-handling system. Specific emphasis on ends of barns, around collection pits, mixing tanks, and manure loading areas. Effective for reducing odors and flies.

Benefits

Open lot: No effect
Freestall scrape: Low
Freestall flush: Low

Open lots and corrals

Rapid manure removal

Removal of wintertime manure and corral bedding from open-lot surface in spring or as quickly as practicable. Manure can then be stockpiled, composted or exported from the dairy.

Benefits

Open lot: Low
Loose housing: Low

Corral harrowing

Corral harrowing to distribute deposited manure, reshape corral surface and/or remove manure from corral surface. Harrowing should be conducted no less than three times per week when weather conditions permit.

Benefits

Open lot: Low

Surface amendments

Use of liquid and dry chemical products to bind or chemically target the conversion of urea to ammonia gas. Effectiveness of production and described use should be specified by manufacture testing. Products may include, but are not limited to, alum, magnesium sulfate and acids.

Benefits

Open lot: High
Freestall scrape: Low
Freestall flush: Low

In-corral composting/stockpiling

Stockpiling and subsequent drying and potential decomposition of winter manure and bedding in corral through summer and fall. Practice promotes the timely stacking and cleaning of corral surfaces.

Benefits

Open lot: Low

Summertime deep bedding

One-time application of 6 inches of straw on open corral surface. An approximate 40% reduction in ammonia emission is achieved. This practice employs a layer of straw to prevent urine and feces from collecting in the same area in the open lot. Feces deposited on straw are allowed to dry and thus shed liquids if urinated upon. Ammonia emissions are reduced by minimizing the time that urine and feces are in contact, during which urea can be converted to ammonia.

Benefits

Open lot: Moderate

Animal nutrition

Manage dietary protein

With the assistance of a professional nutritionist, develop and follow a feeding strategy that more closely follows National Research Council guidelines and meets the herd's production requirement. Incorporate phase feeding, analyze all feeds, measure milk urea nitrogen (MUN) regularly or use appropriate amino acids or enzymes.

Benefits

Open lot: Low
Freestall scrape: Low
Freestall flush: Low

Composting practices

Alum incorporation

Regular incorporation of aluminum sulfate with fresh material to reduce ammonia volatilization. Dissolved phosphorus is also reduced in the applied product.

Benefits

Open lot: Moderate
Freestall scrape: Moderate
Freestall flush: Moderate

Manipulation of the carbon-to-nitrogen ratio

Management and material selection to ensure that the carbon-to-nitrogen ratio is greater than 35:1 in the finished compost material. Lower carbon-to-nitrogen ratios promote greater ammonia volatilization.

Benefits

Open lot: Moderate
Freestall scrape: Moderate
Freestall flush: Low

Composting with windrows

Aerobic decomposition of manure or other organic materials placed in long rows. Can be actively turned windrows, passive windrows, actively aerated windrows or passively aerated windrows.

Benefits

Open lot: No benefit
Freestall scrape: No benefit
Freestall flush: No benefit

Composting with static piles

Engineered composting system through the aerobic decomposition of manure or other organic materials placed in long rows that are not turned or mixed but have aeration pipes that improve air transfer. Bulking agents, such as shredded wood, should be used to ensure pile porosity.

Benefits

Open lot: Low
Freestall scrape: Low
Freestall flush: Low

Forced-aeration composting

Engineered composting method using long rows or containers in which air is drawn or forced into the piles by using mechanical blowers. These piles are not turned. Make sure air is dispersed evenly through the pile. Bulking agents, such as shredded wood, should be used to ensure pile porosity.

Benefits

Open lot: Moderate
Freestall scrape: Moderate
Freestall flush: Low

Land application practices

Soil injection: slurry

Placement of manure slurry (manure of 8%–15% solids) or separated solids beneath the soil surface with a minimum of mixing or stirring of the soil. Injection of slurry or separated solids reduces ammonia emissions, odor and flies. The nitrogen value of the slurry will be 15%–40% greater than if the manure is not incorporated.

Benefits

Open lot: Moderate
Freestall scrape: High
Freestall flush: Moderate

Incorporation of manure within 24 hours

Tilling of field surface following liquid or solid manure application within 24 hours after beginning the manure application. Also effective in reducing hydrogen sulfide emissions and fly propagation.

Benefits

Open lot: Moderate
Freestall scrape: Moderate
Freestall flush: Moderate

Irrigation with freshwater immediately after applying manure

Pumping fresh water immediately after applying manure helps incorporate manure into the soil and reduces ammonia volatilization.

Benefits

Open lot: Low
Freestall scrape: Low
Freestall flush: Low

Low energy and pressure application systems (LEPA systems)

Center pivot and liner-move irrigation strategy that applies liquids at low pressures using drop nozzles. Larger droplets result in lower emissions but may cause infiltration problems in some soils. Designed systems and sprinkler packages should not exceed 35 psi. Low-pressure overhead sprinklers and wheel lines do not qualify as LEPA technologies. Also effective on hydrogen sulfide and odor.

Benefits

Open lot: Moderate
Freestall scrape: Moderate
Freestall flush: Moderate

Freshwater dilution

Dilute irrigated wastewater by a minimum of 50% (waste to fresh water in a 1:1 ratio) during all irrigation events. Dilutions can be made in approved mixing pond or chemigation systems.

Benefits

Open lot: Low
Freestall scrape: Low
Freestall flush: Low

Pivot drag hoses

Low-pressure application method that allows the liquid to be applied on the soil surface directly in the row. This method decreases the amount of liquid lost to wind drift and decreases the energy costs associated with pumping enough liquid to maintain the high pressures required for the impact heads. Systems should use pressure regulators or ball valves to regulate flow from drag hoses. Also effective on hydrogen sulfide and odor.

Benefits

Open lot: Moderate
Freestall scrape: Moderate
Freestall flush: Moderate

Practices not frequently considered

In-house separation

Specialized floor design allowing fecal material to remain in place while urine is removed. This practice uses floor designs that prevent urine and feces from collecting in the same area within the freestall barn. Ammonia emissions are reduced by minimizing the time that urine and feces are in contact, during which urea can be converted to ammonia.

Benefits

Open lot: No benefits
Freestall scrape: Moderate
Freestall flush: No benefit

Anaerobic digester

Treatment system that anaerobically digests organic matter from manure and by using bacteria converts it into methane. The methane may then be used to generate electricity or to replace natural gas as a fuel. A steady supply of manure is needed. Typically there is no change in nutrient concentration without additional treatment. Effective in reducing volatile organic compounds, biological oxygen demand and odor.

Benefits

Limited in any housing system

Sequencing batch reactor

Single-tank treatment system that allows for the sequencing of anaerobic, anoxic and aerobic conditions in the tank by scheduling the feeding and aeration of wastewater. Successful systems have been documented to reduce the total nitrogen in animal wastewater by 85%. Also effective in reducing volatile organic compounds, biological oxygen demand and odor.

Benefits

Open lot: Moderate
Freestall scrape: High
Freestall flush: High

Lagoon nitrification and denitrification system

Engineered lagoon modification or stand-alone system designed and operated to convert wastewater ammonia to nitrate and then to nitrogen gas. Quarterly monitoring of inflow and outflow nitrogen species is required to track system performance. Also effective in reducing volatile organic compounds, biological oxygen demand and odor.

Benefits

Open lot: Low
Freestall scrape: High
Freestall flush: High

Fixed-media aeration system

Stand-alone treatment system designed and operated to convert wastewater ammonia to nitrate by growing bacteria on a medium or substrate. Several systems have been shown to denitrify wastewater nitrate into nitrogen gas. Also effective in reducing volatile organic compounds, biological oxygen demand and odor.

Benefits

Open lot: Low
Freestall scrape: High
Freestall flush: High

Forced-aeration composting with biofilter

Engineered composting method in which air is drawn through the compost and discharged into a biofilter composed of long rows or containers of carbon material. These piles are not turned. Bulking agents, such as shredded wood, should be used to ensure pile porosity. This practice works by filtering volatile compounds and ammonia, then allowing aerobic microorganisms to degrade the compounds.

Benefits

Open lot: Moderate
Freestall scrape: Moderate
Freestall flush: Low

Subsurface irrigation

Specialized irrigation method that allows for precise applications of liquid to the root zone of the plant. System requires a specialized filtering system to handle wastewater solids. Specialized wastewater-approved drip lines should be used to prevent clogging. Also effective on hydrogen sulfide and odor. The nitrogen value of the wastewater is 15%–40% greater than if the manure is not incorporated.

Benefits

Open lot: Moderate
Freestall scrape: Moderate
Freestall flush: Moderate

Ammonia control best management practices checklist

Circle your practices. See text for descriptions of each.

	Open lot	Freestall flush	Freestall scrape	Years used
Liquid manure storage and treatment				
Synthetic lagoon cover	Moderate	High	High	
Geotextile cover	Moderate	Moderate	Moderate	
Solids separation	Low	Low	Low	
Separate slurry/liquid basins	Low	Moderate	No benefit	
Aerated lagoon	Moderate	Moderate	High	
General practices				
Vegetative or wooded buffer: established	Moderate	Moderate	Moderate	
Vegetative or wooded buffer: establishment	Low	Low	Low	
Freestall barns				
Scrape built-up manure	No benefit	Low	Low	
Open lots and corrals				
Rapid manure removal	Low			
Corral harrowing	Low			
Surface amendments	High	Low	Low	
In-corral composting	Low			
Summertime deep bedding	Moderate			
Animal nutrition				
Manage dietary protein	Low	Low	Low	
Composting practices				
Alum incorporation	Moderate	Moderate	Moderate	
Carbon-to-nitrogen ratio manipulation	Moderate	Moderate	Low	
Windrow composting	No benefit	No benefit	No benefit	
Static pile composting	Low	Low	Low	
Forced-air composting	Moderate	Moderate	Low	
Forced-air composting with biofilter	Moderate	Moderate	Low	

	Open lot	Freestall flush	Freestall scrape	Years used
Land application practices				
Slurry injection	Moderate	High	Moderate	
Soil incorporation within 24 hours	Moderate	Moderate	Moderate	
Irrigation following application	Low	Low	Low	
Low-pressure application systems	Moderate	Moderate	Moderate	
Freshwater dilution	Low	Low	Low	
Pivot drag hoses	Moderate	Moderate	Moderate	
Practices not frequently used				
In-barn separation	No benefit	Moderate	No benefit	
Anaerobic digester	Limited	Limited	Limited	
Sequencing batch reactor	Moderate	High	High	
Lagoon nitrification/denitrification	High	High	High	
Fixed-media aeration	High	High	High	
Subsurface irrigation	Moderate	Moderate	Moderate	

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