Effects of Sodium Bisulfate on Alcohol, Amine, and Ammonia Emissions from Dairy Slurry

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Species: Dairy Cows
Use Area: Animal Housing
Technology Category: Chemical Amendment
Air Mitigated Pollutants: Ammonia, Amines, Alcohols

Description:

While research efforts in the past have focused on control technologies that deal with liquid dairy waste storage and treatment, ongoing research identified fresh slurry in the animal housing areas to be a major source of volatile organic compounds (VOC) and ammonia. Therefore, management practices have to be implemented to effectively address emissions from fresh slurry (Dragosits et al., 2002).

Alcohols are produced during anaerobic fermentation in the cow's rumen by microbial strains like *Streptococcus bovis* and *Ruminococcus albus*. Fresh slurry contains both of these alcohols and many VOC forming bacteria. Environmental drivers like pH, temperature, and oxygenation of the slurry determine both microbial activity and physical processes at which alcohols are produced, metabolized by bacteria, and transferred from liquid to gas phase. The production and emissions of gaseous ammonia and from animal manure is dependent on urea content in urine, the pH and temperature of the manure and urease activity (Monteny et al., 1998; Gay and Knowlton, 2005). Therefore, effective emissions mitigation must address at least one of the main environmental drivers (e.g., pH) to effectively disrupt microbial and enzymatic activity and reduce gas release into the atmosphere (Jongebreur and Monteny, 2001).

Sodium bisulfate (NaHSO4, SBS) is extensively used in the poultry industry to reduce ammonia and bacterial levels in litter. It is also used in the dairy industry to reduce ammonia emissions and bacterial counts in bedding, prevent environmental mastitis, and calf respiratory stress.

From an air quality perspective, the main effect of SBS is the reduction of the manure pH to a level that is not conducive to the propagation of bacteria that form VOCs. Similarly, ammonia formation is markedly inhibited.

Sodium bisulfate (aka Parlor Pal, Jones-Hamilton Co.) is a dry granular acid applied to dairy drylot corrals with tractor driven fertilizer spreaders or by hand application for the control of ammonia, methanol and ethanol.

Mitigation Mechanism:

Sodium Bisulfate is hygroscopic and as ambient moisture is adsorbed into the SBS bead, the component dissolves into its sodium (Na^+), hydrogen (H^+), and sulfate ($SO4^-$) constituents.. The hydrogen ion reduces the pH of the bedding or manure and protonates the ammonia molecule converting it to ammonium ($NH_3 + H^+ \rightarrow NH_4^+$). The ammonium is then bound by the sulfate component forming ammonium sulfate (Ullman et al., 2004). The newly formed ammonium sulfate does not aerosolize but is retained in the manure in its solid form (similar to ammonium sulfate inorganic fertilizer). Theoretically, every 100 kg of SBS binds 14 kg of ammonia based on reaction:

$2\ NaHSO_4 + 2\ NH_4OH \rightarrow (NH_4)_2SO_4 + Na_2SO_4 + 2\ H_2O$

Sodium and hydrogen ions exert synergistic negative pressure on the bacterial populations within the manure decreasing total aerobic population counts by 2-3 logs (Pope and Cherry, 2000) This decrease in bacterial population also serves to further decrease urease concentrations in the manure slurry, leading to additional ammonia reductions (Ullman et al., 2004).

Sodium bisulfate is approved by the FDA for animal and human food use and by the EPA as a surface amendment for ammonia reduction and general bacterial reduction.

Applicability:

Recent dairy emission research conducted in our lab has identified alcohols (methanol and ethanol) as the major VOC group originating from fresh waste and fermented feedstuffs (Shaw et al., 2007; Sun et al., 2008). Effective control of alcohols and ammonia emissions could help meeting regulatory standards, satisfy public concerns, and improve local and regional air quality.

The present study was conducted at the University of California, Davis using surface isolation flux chambers. The dose responses of three potential SBS treatment levels were compared vs. the untreated control on ammonia, amine, and alcohol air emissions from dairy slurry mix (Sun et al., 2008).

Surface application of SBS markedly decreased ammonia and both methanol and ethanol emission fluxs ($P<0.01$) from fresh dairy slurry in a dose-response manner (Table 1). The three-day average ammonia flux from the control (no SBS applied) and the three different SBS surface application levels of 0.125, 0.250, and 0.375 kg m^{-2} were 513.4, 407.2, 294.8, and 204.5 mg hr^{-1} m^{-2}, respectively. The ammonia emission reduction potentials were 0, 21, 43 and 60%, respectively. Methanol and ethanol emissions also decreased with an increase in the amount of SBS applied. The three-day average methanol emissions were 223.7, 178.0, 131.6 and 87.0 mg hr^{-1} m^{-2} for SBS surface application level of 0, 0.125, 0.250 and 0.375 kg m^{-2} with corresponding reduction potentials of 0, 20, 41, and 61%, respectively. Similar emission reduction potentials of 0, 18, 35, and 58% were obtained for ethanol. Sodium bisulfate has been shown to be effective in the mitigation of ammonia and alcohol emissions from fresh dairy slurry.

Table1. Ammonia, methanol, and ethanol emissions and reduction potential from three levels of SBS treated vs. untreated slurry.

	SBS treatment (kg/100 m^2)					
	0	**12.5**	**25**	**37.5**	**SEM**	**P-value**
Ammonia						
Emission rate (mg/hr/m^2)	513.4	407.2	294.8	204.5	18.1	<0.01
Reduction potential (%)	N/A	21	43	60		
Methanol						
Emission rate (mg/hr/m^2)	223.7	178.0	131.6	87.0	6.2	<0.01
Reduction (%)	N/A	20	41	61		
Ethanol						
Emission rate (mg/hr/m^2)	356.4	291.2	232.4	150.8	11.2	<0.01
Reduction (%)	N/A	18	35	58		

Limitations:

Sodium bisulfate is a mineral acid salt. Appropriate measures, as defined by the chemical supplier, should be used during the handling of SBS.

In locations that are sensitive to salt or areas with existing high salt loading in soils, applications of SBS should be considered with care because sodium is one of its components. Application at high rates could cause formation of nitrous oxide.

In addition, SBS must be applied consistently to manure to maintain constant emission reduction as the substance looses its effectiveness over time.

Cost:

Bulk cost of product delivered to the farm is $660.00/ ton. Application at 50 to 75 lb / 1000 ft^2 2X / week equates to costs of between $33.00 to 49.50 / 1000 ft^2 / week. Treatment of heavy use areas, approximately 30% of the total pen area, reduces total pen cost by 70%. Cost / cow assuming 4 cows / 1000 ft^2 of pen area would be $2.48 to $3.71 / week treating only the heavy use areas.

Implementation:

There are no special requirements to implement this program. A fertilizer type spreader is required.

Technology Summary:

Sodium bisulfate application is an acidifier method that can effectively mitigate ammonia and alcohols emissions from dairy slurry.

Additional Resources:

http://www.jones-hamilton.com/products.html

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