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Richard K. Koelsch
University of Nebraska - Lincoln, rkoelsch1@unl.edu

Bryan Woodbury
USDA Meat Animal Research Center

David Stenberg
Dawson County Cooperative Extension, PO Box 757, Lexington, NE

Daniel Miller
USDA Meat Animal Research Center

Dennis Schulte
University of Nebraska - Lincoln, dschulte1@unl.edu

UNL's Livestock Environmental Issues Committee
Includes representation from UNL, Nebraska Department of Environmental Quality, Natural Resources Conservation Service, Natural Resources Districts, Center for Rural Affairs, Nebraska Cattlemen, USDA Ag Research Services, and Nebraska Pork Producers Association.

Contact:
Chris Henry
217 LW Chase Hall
University of NE
Lincoln, NE 68583
(402) 472-6529
chenry@.unl.edu

TOTAL REDUCED SULFUR CONCENTRATION IN BEEF CATTLE FEEDLOTS

Richard K. Koelsch[1], Bryan Woodbury[2], David Stenberg[3], Daniel Miller[2], and Dennis Schulte[1]
Biological Systems Engineering Dept., Chase Hall, University of Nebraska, Lincoln, NE 68583-0726
USDA Meat Animal Research Center, PO Box 166, Clay Center, NE 68933-0166
Dawson County Cooperative Extension, PO Box 757, Lexington, NE 68850-0757

INTRODUCTION

In 1997, the Nebraska Department of Environmental Quality amended its Title 129 Air Quality Regulations to establish a regulatory threshold for Total Reduced Sulfur (TRS) concentrations under ambient conditions. These thresholds are set at "10.0 parts per million (10.0 PPM) maximum 1 minute average concentration or 0.10 parts per million (0.10 PPM) maximum 30-minute rolling average". Two agricultural regions of Nebraska with significant cattle finishing in open feedlots came under scrutiny for possible rule violations. In one situation, area feedlots were asked to prepare and implement a TRS control plan.

This growing scrutiny prompted field survey of TRS levels in the vicinity of typical feedlots in central Nebraska. The intent of this research was compare those observations against current regulatory thresholds for Nebraska, and identify factors that influence TRS concentration. The paper summarizes average TRS concentrations, number of observations exceeding regulatory threshold values, and observed relationships between TRS levels and time of day, air temperature and feedlot surface moisture conditions.

PROCEDURES

A field survey was implemented to provide a preliminary review of sulfur emissions in the vicinity of feedlots. Two Jerome 631-S analyzers with memory modules and a dynamic range of 1 ppb to 50 ppm were used to survey TRS concentrations at 15-minute intervals approximately 1 meter from the ground surface. An on-site meteorological weather station (MicroMet Station) was used to collect wind speed, wind direction, air temperature, barometric pressure, and relative humidity at 15-minute intervals.

The Jerome meter responds to hydrogen sulfide (H_2S), alkyl sulfides, disulfides, mercaptans, and cyclic sulfur compounds.

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Winegar and Schmidt (1988) showed that the response of the Jerome 631-X meter was 100% to H_2S and 0 to 45% to other reduced sulfur gases when exposed to calibrated mixtures. The meter response is calibrated to an H_2S equivalent. The data presented in our paper are described as TRS reported as an H_2S equivalent. We made no effort to identify specific reduced sulfur gases during our field survey.

Surveys were conducted on three feedlots for one-week periods each under spring, summer and fall conditions during 2000. A perimeter survey was conducted upon arrival and departure consisting of TRS measurements taken at 0.2-mile intervals on all four township mile lines surrounding the feedlot. Within the feedlot, data were collected at 15-minute intervals at three locations, 1) center point within the feedlot among the animal pens, 2) downwind edge (based upon prevailing winds) of the feedlot, and 3) downwind edge of the runoff holding pond. Typically, one Jerome meter was located at the center of the feedlot for the entire week and the second meter was moved among the three locations for two to three day intervals. Measurements were made at 15-minute intervals at these three locations.

A 10-week survey was conducted during the spring of 2001 at a single location at the center of one feedlot with a Jerome meter. During the sampling period, on-site weather data were collected at 15-minute intervals and were matched with TRS observations based upon time.

The authors wish to acknowledge the efforts of Joel Stenberg and April Eisenhauer in the collection and analysis of the data for this project.

Winegar, E. D. and C. E. Schmidt. 1988. Analyzing using a Jerome 631-X portable hydrogen sulfide sensor: Laboratory and field evaluation. Report to Arizona Instruments, Corp. Applied Measurement Science. Fair Oaks, CA.

RESULTS

The average TRS levels[1] at the township mile lines surrounding the three feedlots ranged from 0.002 to 0.006 PPM (parts per million by volume). The peak observation was 0.019 PPM, a factor of five less than the lowest Nebraska regulatory threshold for TRS. The peak values were from readings taken at the township roads directly adjacent to the feedlot facilities. Average TRS levels on locations immediately adjacent to the feedlots were within 0.002 PPM of the averages observed at more distant locations. The perimeter observations provided no indications of TRS levels that might exceed regulatory thresholds.

Within the feedlots' interiors, 15,800 TRS observations were collected (data summarized in Table 1). Out of a total of 12,100 observations at the centers of the feedlots, only 60 observations exceeded the 0.1 PPM regulatory threshold and only two observations suggested that the TRS concentration remained at this level for a 30-minute period. TRS levels exceeded regulatory thresholds with similarly low frequencies at the downwind edges of the holding ponds and feedlots. Only two observations exceeded the 10 PPM TRS regulatory threshold at any of the locations, both at the holding pond edge. The very low levels of observed TRS concentration within the feedlot facilities suggest that neighboring property owners located immediately adjacent to a feedlot are unlikely to experience TRS levels exceeding regulatory thresholds.

The average TRS levels observed in the feedlots were very low. Perimeter readings for locations upwind of the feedlots suggested that a TRS background level of 0.003 to 0.005 PPM existed during the sampling times. By comparison, average readings in the middle of the feedlot ranged from 0.002 to 0.037 PPM. Observations near the edges of the feedlots and the runoff holding ponds produced average TRS concentrations equal to or lower than observed at the center locations. Thus, the

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University of NE
Lincoln, NE 68583
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chenry@.unl.edu

feedlot produced average TRS levels that ranged from near background to about one order of magnitude greater than background. Feedlots and holding ponds do not appear to be a source of significant TRS concentrations that are likely to impact neighbors, including neighbors in the immediate vicinity of the feedlot.

Several environmental factors have the potential to impact TRS concentrations. TRS levels appear to be related linearly to air temperature between 0 and 35ºC (Figure 1). A 20ºC rise in air temperature correlated to a doubling of observed TRS concentration. Increased soil temperatures should contribute to increased soil microbial activity and greater production of volatile sulfur compounds. Soil temperature, not measured in this experiment, would be expected to track changes in air temperature.

TABLE 1. Summary of TRS[1] Observations Within Three Nebraska Feedlots.

	Feedlot #1			Feedlot #2			Feedlot #3			
	Spring	Summer 2000	Fall [b]	Spring	Summer 2000	Fall	Spring	Summer 2000	Fall	Spring 2001
Center Location										
Observations > 10 PPM	0	0	0	0	0	0	0	0	0	0
Observations > 0.1 PPM	7	3	0	17	3	10	1	13	3	3
3 consecutive obs. >0.1	0	0	0	2	0	0	0	0	0	0
PPM[a]	0.010	0.012	0.001	0.028	0.037	0.009	0.006	0.014	0.00	0.006
Average TRS concentration	902	320	190	904	683	640	1249	558	2	5803
Number of observations									854	
Feedlot Edge										
Observations > 10 PPM	0	0	0	0	0		0	0		
Observations > 0.1 PPM	9	1	0	1	0		0	4		
3 consecutive obs. >0.1	0	0	0	0	0		0	0		
PPM[a]	0.013	0.009	0.005	0.007	0.006		0.008	0.008		
Average TRS concentration	251	343	496	184	176		118	180		
Number of observations										
Holding Pond Edge										
Observations > 10 PPM	1	0		0	1	0	0	0		
Observations > 0.1 PPM	2	2		1	4	0	1	3		
3 consecutive obs. >0.1	0	0		0	0	0	0	0		
PPM[a]	0.000	0.009		0.009	0.006	0.002	0.012	0.008		
Average TRS concentration	228	255		355	283	353	283	185		
Number of observations										

[a]Three consecutive observations at 15-minute intervals would approximate situations where TRS levels exceeded the 0.1 PPM 30-minute average regulatory threshold for Nebraska.
[b]Most observations occurred after a six-inch blowing snow.

[1] TRS concentrations are reported as an H_2S equivalent. See second paragraph in Procedures section.

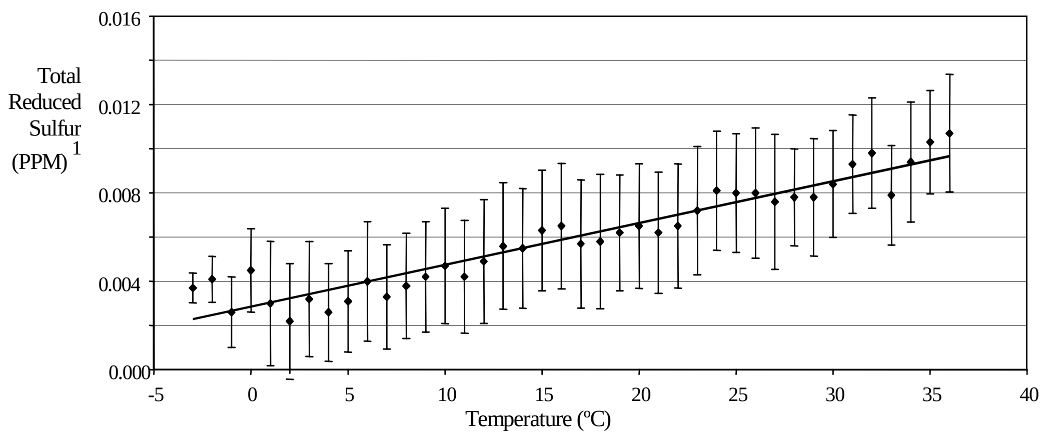

FIGURE 1. Average TRS concentration (± one St. D.) vs. Air Temperature for Feedlot #3 during Spring 2001.

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A strong diurnal pattern was observed for TRS concentration (Figure 2). Peak concentrations were observed during mid-afternoon and the lowest concentrations occurred during early morning hours. Afternoon concentrations were approximately twice those observed during the early morning. Several factors would likely impact daily TRS concentrations. Typically, wind speed and stability of the air influences dilution of volatile emissions. However, conditions contributing to the least dilution and greatest concentration would be anticipated during the early morning hours. Greater instability and more dilution is expected in late afternoon. This is counter to the observed diurnal trend. Soil surface temperature, which impacts microbial action and TRS production, and animal activity, which disturbs the pen surface, would likely follow a pattern comparable to that observed for TRS. Thus, soil temperature and animal activity were more likely controlling factors for the observed diurnal TRS levels at the feedlot's center.

It was anticipated that feedlot surface moisture would influence TRS concentration. Wet feedlot conditions, conducive to bacterial activity, and anaerobic conditions should result in greater TRS production. Feedlot surface conditions in Nebraska vary dramatically based upon weather conditions. The extended sampling during the spring of 2001 was conducted in hopes of capturing the effects of volatile sulfur production under muddy feedlot surface conditions.

Four rainfall events occurred during the spring 2001 sampling period. TRS levels up to 3 days prior to and 6 days after significant (>15mm) rainfall events are summarized in Table 2. For much of the early spring, wet feedlot conditions were common. The TRS concentration for the days following rainfall events did not rise above the levels observed prior to or on the day of rainfall events (see Figure 3 and Table 2). No increase in TRS levels could be attributed to wet feedlot conditions.

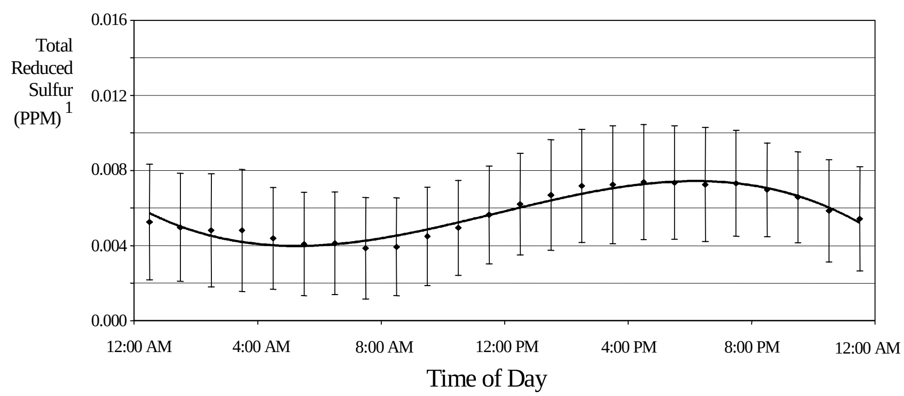

FIGURE 2. Average TRS concentration vs. Time of Day for Feedlot #3 during

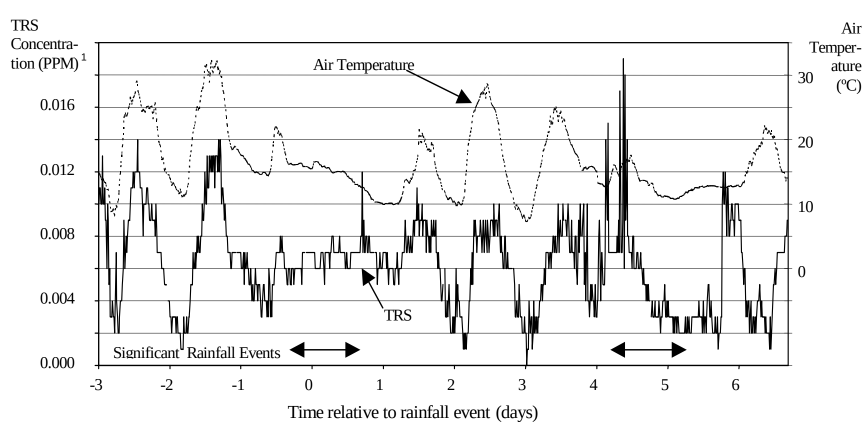

FIGURE 3. Impact of Rainfall on TRS Concentration for Feedlot #3 (Event 4, May 27 –

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CONCLUSIONS

Based upon the observations made in this survey of Total Reduced Sulfur levels in the vicinity of cattle finishing feedlots, the following conclusions were drawn:

TRS concentration in the vicinity of beef cattle feedlots is unlikely to exceed Nebraska regulatory thresholds.

TRS levels increase linearly with increasing air temperature. It is anticipated that warming of feedlot surface is partially responsible for the increased production of TRS.

A diurnal pattern was observed for TRS concentration with peak levels occurring in mid-afternoon. This pattern is also likely attributable to varying feedlot surface temperature.

TRS level was not influenced by rainfall events. Wet feedlot surface conditions do not appear to increase TRS concentrations.

TABLE 2. Summary of Daily TRS[1] Level Relative to Rainfall Events at Feedlot #3.

Day	Event 1		Event 2		Event 3		Event 4	
	Rainfall (mm)	Average TRS (PPM)	Rainfall (mm)	Average TRS (PPM)	Rainfall (mm)	Average TRS (PPM)	Rainfall (mm)	Average TRS (PPM)
-3	0.4	0.004	0.8	0.007		0.008		0.008
-2	0.1	0.003	14.9	0.006		0.007		0.007
-1		0.004	5.2	0.006	1.2	0.007	9.6	0.006
0	16.0	0.002	72.9	0.004	17.7	0.007	40.4	0.007
1	5.8	0.003	9.1	0.007		0.007		0.007
2		0.003		0.007	0.7	0.007	0.1	0.006
3		0.002		0.004		0.006		0.006
4		0.003			0.2	0.005	17.9	0.007
5						0.007	2.2	0.003
6	0.2	0.007				0.008	1.2	0.006

[1] TRS concentrations are reported as an H_2S equivalent. See second paragraph in Procedures section.