LIVESTOCK FACILITY EMISSION AND ODOR MONITORING

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Introduction

Air quality has moved to the forefront of environmental issues facing Wisconsin livestock producers. State agencies are exploring how livestock facility emissions and odors are impacting air quality. Producers will soon be faced with regulatory pressure to manage livestock facilities and feedlots to comply with air quality standards. The Wisconsin livestock industry has limited quantitative data to document actual on-farm emissions associated with housing facilities and feedlots. As regulatory agencies begin assembling air quality standards, the livestock industry has requested a baseline be identified for ammonia, hydrogen sulfide and odor currently generated from a variety of real farm facilities. Minimizing livestock facility impact on air quality will benefit public health, the environment and improve public perception of livestock agriculture.

Ammonia is emitted from livestock housing facilities, manure storage areas, and manure / fertilizer application areas. Ammonia (N gas) that is emitted to the atmosphere from agricultural areas either remains in the air as particulate haze or gets re-deposited back to land and water. Ammonia emission concerns include: 1) atmospheric particulates that cause haze and stimulate human respiratory health issues; and 2) ecosystem N fertilization where extra N causes plant species to shift from native to grassy, soil acidification, and adds extra N into the Mississippi River / Gulf of Mexico surface water system where a hypoxia zone has developed.

Hydrogen sulfide is a product of anaerobic decomposition of organic matter. Liquid livestock manure storage areas generate hydrogen sulfide. Hydrogen sulfide is toxic and causes human and animal health concerns. Exposure to hydrogen sulfide will cause dizziness, headache, nausea @ 50 ppm; and death from respiratory paralysis @ 1,000 ppm. The OSHA indoor workplace standard for hydrogen sulfide is 10 ppm for an 8 hour day. Periodically, farm workers are overcome by manure pit gas and die as a result of hydrogen sulfide.

Odor from livestock facilities arises from a mixture of different gases, existing at low concentrations. The actual odor can be from any combination of manure, dust, decaying feed, and other material. Odors evoke a wide range of physical and emotional reactions, both positive and negative. Many livestock facility odors are identified by the surrounding neighborhood as negative. Continued exposure and inhalation of very strong odors can cause olfactory fatigue. When people experience odor fatigue their sense of smell is less sensitive (Janni, Jacobson, Schmidt, Norlien, and Rosenstein, 2002).

Hydrogen sulfide, ammonia and odor from livestock facilities can all have an adverse impact on air quality. Table 1 shows Atmospheric gas concentrations used as thresholds for adverse air quality impacts (Baumgartner, 2004).

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Table 1. Atmospheric gas concentration thresholds for adverse air quality impacts

Constituent	Time-Averaging Interval	Time-Averaged Concentration	Reference
Hydrogen Sulfide	Hour	5.3 µg/m3	Odor Threshold Concentration [3]
	Day	335 µg/m3	WI Ambient Standard [4]
	Year	2 µg/m3	U.S. EPA Reference Concentration [5]
Ammonia	Hour	1070 µg/m3	Odor Threshold Concentration[2]
	Day	418 µg/m3	WI Ambient Standard [3]
	Year	100 µg/m3	WI Ambient Standard [3], U.S. EPA Reference Concentration [4]
Odor	Hour	25 OU (d/t)	Odor Threshold Intensity [6]
	Hour	72 OU (d/t)	Annoyance Threshold Intensity [5]

2. Nagy G. Z. 1991. The odor impact model. *Journal of Air & Waste Management Association* 41(10): 1360-1362.
3. Minnesota Environmental Quality Board. 1999. *A Summary of the Literature Related to the Social, Environmental, Economic and Health Effects: Volume 2.* Generic Environmental Impact Statement on Animal Agriculture, Prepared by the University of Minnesota, September 1999. Table 1 presents the geometric mean of the lower and upper odor threshold concentrations obtained from this reference.
4. Section NR 445 of the Wisconsin Administrative Code
5. U.S. EPA Integrated Risk Information System (www.epa.gov/iris)
6. Jacobson L. D. *et al*. 2000. Development of an odor rating system to estimate setback distances from animal feedlots: odor for feedlots setback estimation tool (*OFFSET*). Final Report. Prepared by the Department of Biosystems and Agricultural Engineering, University of Minnesota, St. Paul, MN. 26 pp.

Purpose

The purpose of this paper is to summarize an air quality monitoring project conducted on a western Wisconsin swine finishing operation. Environmental consultants for this project were John Baumgartner and Charles Gantzer from Baumgartner Environics, Olivia, MN. Monitoring conducted during June 21-22, 2004, represents a snapshot in time of emissions generated from the farm. A full report for this project, “Air Quality Impacts at Three Hog Feedlots”, was prepared by Baumgartner and is available on the University of Wisconsin - Discovery Farms Program website.

Project Methods

In June of 2004, the University of Wisconsin - Discovery Farms Program coordinated air quality monitoring for ammonia, hydrogen sulfide and odor on a swine farm near Elk Mound, WI. This was a cooperative effort with technical monitoring conducted by Baumgartner Environics, Olivia, MN; WI DNR; with on-site assistance provided by University of Wisconsin - Discovery Farms staff.

Air quality measurements and samples were gathered from 5 swine finishing barns at 3 property locations. Barns were total confinement with mechanical ventilation and manure storage pits below slotted feeding floors. Animal management within barns is “all in – all out”, where feeder pigs are brought in at 50 lbs. and finished to 250 lbs. in 16 week cycles.

On the day of air quality monitoring each feedlot / barn had the following hog population:

Location	Hog numbers	Hog weight (lbs)
Feedlot 1, east barn	320	220
	300	120
Feedlot 1, west barn	600	120
Feedlot 2	800	230
Feedlot 3, north barn	1,000	80
Feedlot 3, south barn	1,000	50

Emission rates for ammonia, hydrogen sulfide and odor were determined for each barn. Ammonia was measured directly from barn exhaust fans, as well as manure pit exhaust fans using gas detection colorimetric tubes. Hydrogen sulfide was measured directly from barn exhaust fans, manure pit exhaust fans, as well as property lines using a Jerome 631-X Hydrogen Sulfide Analyzer. Odor was measured by gathering a bag of air from barn exhaust fans for lab analysis by dynamic olfactometry. Odor was also measured on-site using a Nasal Ranger Field Olfactometer.

Baumgartner used the U.S. EPA. CALPUFF air quality model to estimate odorous gas concentrations present at property lines and nearest neighbor residences.

Results and Discussion

Emission gas flux rates for ammonia, hydrogen sulfide and odor for 5 swine finishing barns are shown in Figures 1 – 3. Flux rates are the amount of gas emitted per square meter of barn floor per time unit. For comparison, each figure shows the average emission flux rate for Minnesota swine finishing barns (Wood, 2001).

Figures 1-3 suggest this farm has typical emissions and that individual barn results vary depending on facility design, hog numbers and hog size. Feedlot 2 had 800 hogs weighing 230 lbs each, and had the highest emission of ammonia, hydrogen sulfide and odor measured directly at the barn. Similarly, the south barn of feedlot 3 had 1,000 hogs weighing 50 lbs each, and had the lowest emission of ammonia, hydrogen sulfide and odor measured directly at the barn. Emission flux rates from the project farm were below the MN average for ammonia and hydrogen sulfide and slightly above the MN average for odor. An evaluation of Figure 3 shows that the project farm had an average odor emission flux of 7.1 odor units (OU), compared to the MN average of 6.5 OU. An annoyance – free odor intensity is defined by the University of Minnesota as a detection threshold of 72 OU or less. The UMN defines an odor intensity of 72 OU as a faint odor, a level that an average person might detect the odor if attention is called to the odor, but the odor would not otherwise be noticed (Baumgartner, 2004).

Figure 1

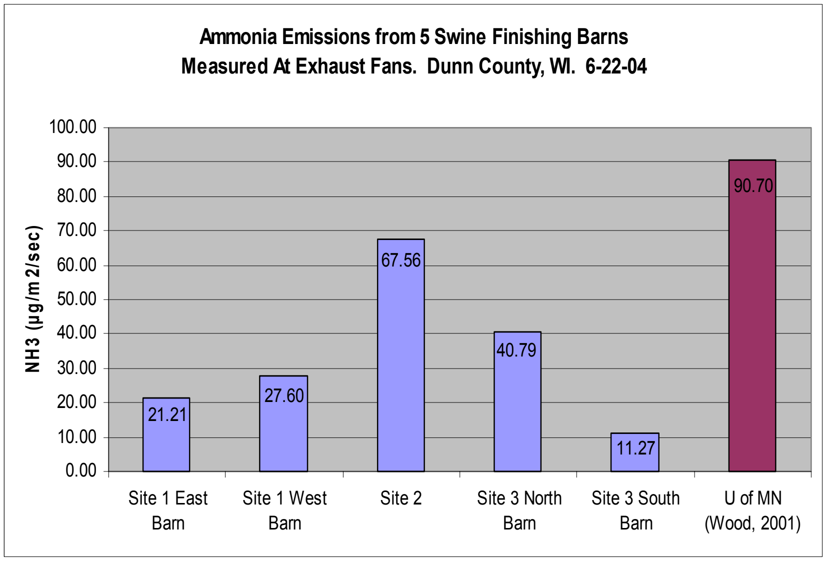


Figure 2

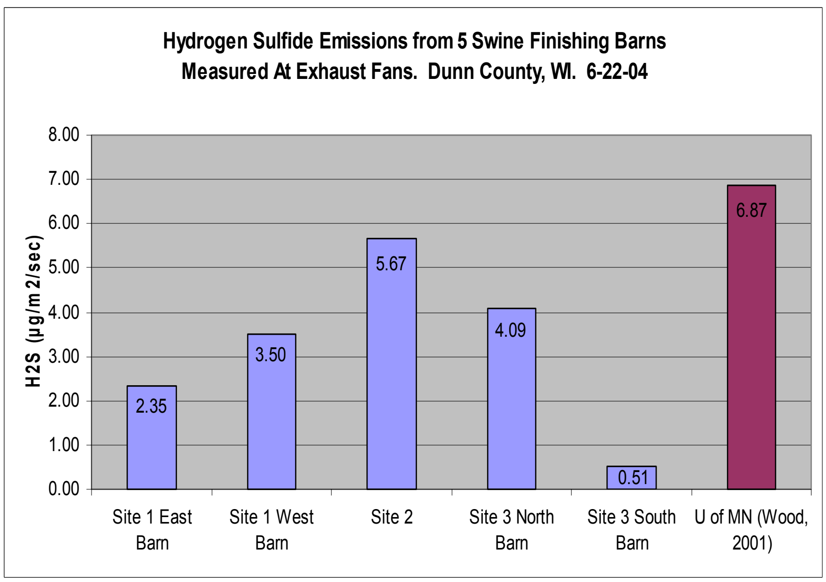
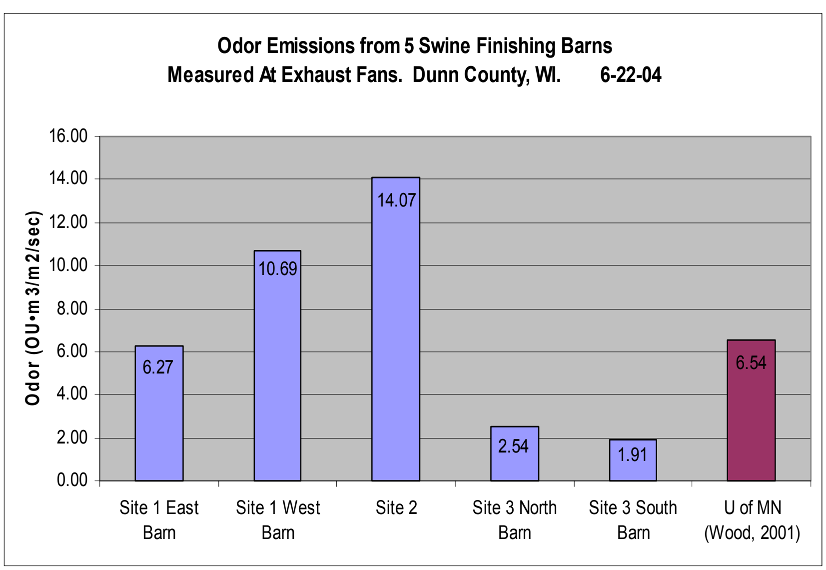


Figure 3



Property line and nearest neighbor hourly emission concentrations for hydrogen sulfide, ammonia and odor are presented for each swine finishing feedlot in Table 2. This table shows the feedlot average, as well as maximum emission rates for each location, per hour. For comparison, the table also includes hourly emission concentration standards for each constituent.

Table 2 shows the project farm has a slightly elevated hourly hydrogen sulfide emission at the property line, a very low hourly ammonia emission at the property line, and an hourly odor emission of +/- 5 units from the standard at the property line. A dilution and distance factor for these gas emissions can be seen in Table 2 as most "nearest neighbor" gas concentrations are considerably less than property line values. All emission values will vary daily and seasonally depending on facility design, hog numbers and size, and weather conditions.

Table 2. Hourly Emission Concentrations At Property Line and Nearest Neighbor For 3 Swine Finishing Feedlots

Location	Hydrogen Sulfide ($\mu g/m^3/hr$)		Ammonia ($\mu g/m^3/hr$)		Odor Intensity (OU, d/t)	
	Avg	Max	Avg	Max	Avg	Max
Feedlot 1						
Property Line	6.2	9.3	52	78	18	27
Nearest Neighbor	0.9	1.3	7	11	3	4
Feedlot 2						
Property Line	8.6	16.7	12	20	15	30
Nearest Neighbor	2.2	6.4	3	11	4	11
Feedlot 3						
Property Line	4.8	13.4	50	133	3	8
Nearest Neighbor	1.2	6.8	14	76	1	6
Threshold / Standard	**5.3**	**5.3**	**1070**	**1070**	**25**	**25**

Summary

Through this project, air quality impacts associated with three existing hog feedlots were assessed. Results indicate that the three hog-finishing sites are not a significant public health concern with regard to hydrogen sulfide and ammonia emissions. Detectable gas concentrations and odor intensities are limited to the immediate vicinity of the feedlot barns. The evaluation also indicates the potential for episodes of detectable, yet non-annoying odors at the property lines for two feedlots and at two nearest neighbor locations (Baumgartner 2004).

This project provided a valuable snapshot in time for the Wisconsin swine industry of hydrogen sulfide, ammonia and odor emissions on 1 farm, over a 2 day period in June. It is recommended that similar emission monitoring be conducted on more farms over a longer time period to assess seasonal differences. As a result of this project, the producer may consider building a bio-filter to demonstrate a BMP for livestock facility odor and emission management.

The study report (Baumgartner, 2004) has been shared with many groups to raise awareness of livestock facility impact on air quality and to set the stage for necessary future research. Further on-farm air quality research is needed to better understand the impact of Wisconsin dairy, swine, beef and poultry housing facilities on air quality. Similarly, further study is needed to better understand the role of agricultural livestock facility emissions on regional air quality.

References

Baumgartner Environics, Inc. 2004. Air Quality Impacts at Three Hog Feedlots. Prepared for University of Wisconsin Discovery Farms Program.
http://www.discoveryfarms.org/corefarms/Harrison/report.pdf

Janni, K., L. Jacobson, D. Schmidt, K. Norlien, and T. Rosenstein. 2002. Livestock and Poultry Odor. Dept. of Biosystems and Agricultural Engineering, University of Minnesota. University of Minnesota Extension.

Wood, S. L. et al. 2001. Odor and Gas Emissions From Animal Production Systems. 2001 ASAE Annual Meeting Paper No. 01-4043. St. Joseph, MI.