Seasonal Variations in NH_3, H_2S, and PM_{10} Emissions from Pig and Poultry Buildings from a Multi-State Project

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1. *Abstract. NH_3, H_2S, and PM_{10} emissions, when expressed on an animal unit (AU = 500 kg animal mass) basis from two Minnesota dry sow buildings measured during one cold and one warm month as well as over a 15 month period, revealed very limited seasonal effects. The seasonal ventilation rates occurring in animal buildings seem to compensate for these seasonal NH_3 concentrations and result is a fairly constant ammonia emission rate. All emission rates reported in this study (NH_3, H_2S, and PM_{10}) fluctuated more in the summer than in the winter probably due to more variability in summer ventilation rates. Also, some high acute emission events were found in the spring and fall which are probably explained by some unique manure management or animal practice event which although not routine or chronic in nature are real and need to be considered by producers when considering if they can meet both CERCLA and Clean Air Act regulations. None of the chronic emissions found from the MN sow barns would exceed either the 100 lbs per day CERCLA reporting threshold or the 100 tons per year Clean Air Act threshold. However, during the acute situations (spikes in emissions) some of the barns may reach 20 to 30 lbs of NH_3 emitted per day per barn and combined with other sources from that production sites including other barns and associated manure storages the combined emissions might approach the 100 lb/day threshold. Thus even with one or two months of data, one may miss an acute emission event if you are not aware of a particular manure or animal management practice in your housing systems that could cause such an event. Knowledge of these acute emission events can only be found by measuring for a full year, which allows these spikes or unusual events to be documented.*

Keywords. *Gaseous Emissions, Dust, Ammonia, Hydrogen Sulfide, Air Quality, Air Pollutants*

Introduction

United States livestock and poultry producers are becoming more concerned over the gases and particulates that are generated and emitted from their animal operations. Of primary interest is the reporting requirement from the Comprehensive Environmental Response, Compensation and Liability Act-CERCLA (or commonly known as the Superfund) if an animal production facility exceeds the 100 lb/day threshold of a hazardous material. Ammonia and hydrogen sulfide are generally considered the limiting hazardous gas compounds for animal operations. Also, the Clean Air Act may restrict other volatile organic compounds (VOCs) and particulate material or dust with a mass medium diameter of 10 microns or less (PM_{10}) emitted from the animal production system to 100 tons /year. Although these regulations have been in place for some time, state and federal regulatory agencies have not enforced these regulation for livestock and poultry operations for a variety of reasons including the very limited research information on the amount of airborne contaminants being emitted from animal facilities and associated manure storage units. However, state and federal regulatory agencies are being pushed by environmental groups and others to enforce these standards so there is an urgent need to determine odor and gas emissions from animal production sites, including buildings.

Airborne contaminants emitted from pig and poultry buildings are difficult to measure not only because of the problems with determining the gas, dust, or odor concentrations but also because of the challenge of accurately measuring building air exchange rates. For these reasons, relatively few studies have reported on ammonia (NH_3), hydrogen sulfide (H_2S), dust (PM_{10}), and odor emission rates from U.S. pig and poultry buildings. Bicudo et al. (2002), reviewed values reported in the literature for these three air pollutants as well as several others. They reported that wide variations exist in all air emission rates reported due to seasonal, diurnal, species, and other factors.

A great deal of concern has been expressed about the estimated ammonia emissions from U.S. agricultural sources derived from the European literature (Battye et al. 1994). Only a few U.S. researchers (Gay et al. 2002; and Ni et al. 2000) have measured ammonia emissions in the United States and have generally found lower values than reported by Battye (Sweeten et al. 2000). Certainly, there is a need for more information on ammonia and other air emissions from US livestock and poultry production systems.

To address the urgent need for gas, odor, and particulate matter emission from actual animal production buildings, funding was secured by a six-state research team from a USDA-IFAFS proposal entitled “Air Pollutants Emissions from Confined Animal Buildings” or APECAB. The main objective of this project was to quantify long-term (yearly) air pollutant emissions from confined animal buildings and establish methodologies for real time measurement of these emissions and build a valid database of air emissions for US livestock and poultry buildings.

MATERIAL AND METHODS

Air emission data reported in this paper was collected during the multi-state APECAB project, which is a collaboration of land-grant universities in Minnesota, Indiana, Illinois, Texas, Iowa, and North Carolina. Notification of funding for this multi-year project was received in the fall of 2001 and data collection began in the fall of 2002. Data collection concluded this past spring (2004) and the project will end in the fall of 2005. The study utilized common instrumentation and protocol. At each measurement site, an instrument trailer was stationed between two similar, mechanically ventilated, confined animal production buildings and emission measurements were quasi-continuous for gas and continuous for PM. Four swine (finishing, gestation, and farrowing production stages) sites were selected along with two poultry (a layer and a broiler) sites. A more thorough description of monitored sites, sampling and calculation protocols can be found in Jacobson, et al. (2004).

Results and Discussion

Seasonal variations in gas and dust emissions are assumed because typically gas and dust concentrations inside animal buildings do vary with time of the year especially in temperate areas of the world like the Midwestern US. Figure 1 shows the NH_3 concentrations for one of the dry sow barns from the Minnesota APECAB site. As the graph shows, NH_3 levels range from 20 to 30 ppm during cold weather and down to <5 ppm during the summer. However, NH_3 emissions for this same barn over the same time period show a much less seasonal effect with cold weather rates averaging around 20 g NH_3 /day/AU and during warm weather up to only 25 or 30 g NH_3 /day/AU (figure 2).

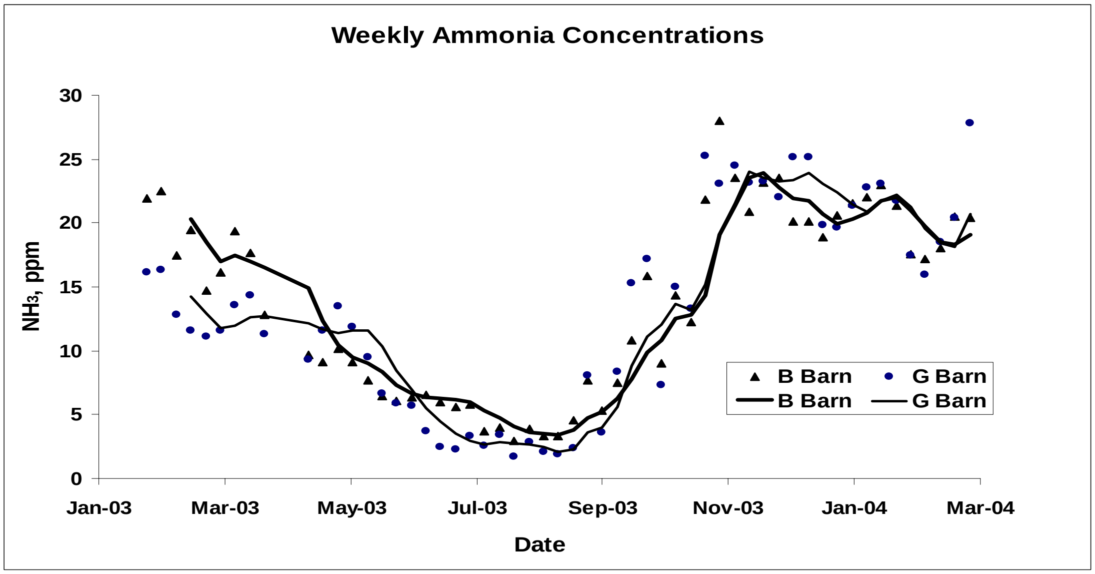


Figure 1. Weekly NH_3 concentrations for the 15-month period for the MN breeding barn

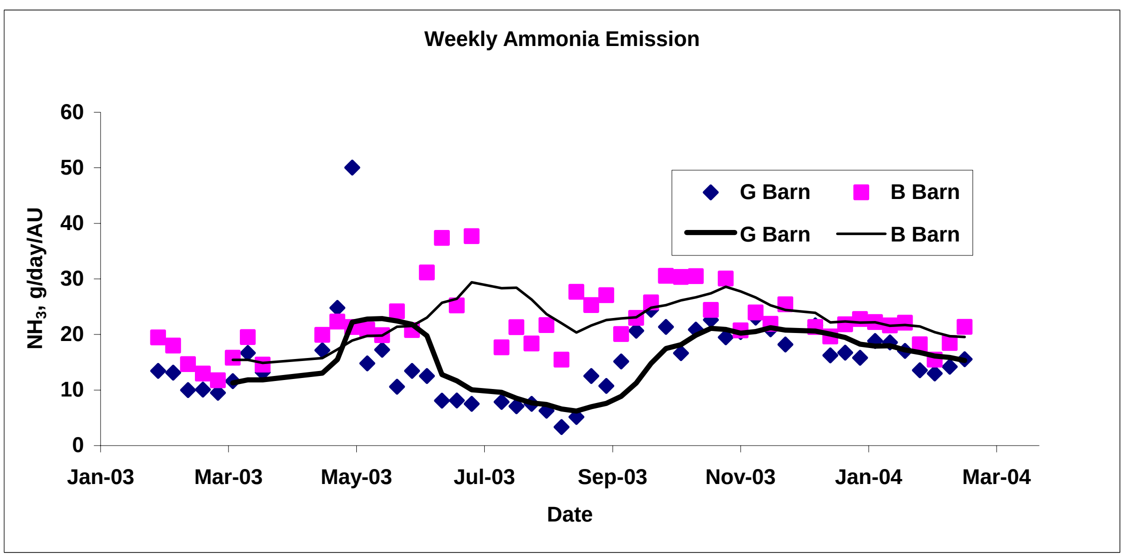


Figure 2. Weekly NH_3 emissions for the 15-month period for both the MN breeding and gestation barns

The H_2S concentrations inside the Minnesota dry sow barns show a similar seasonal trend as NH_3, with winter levels near 1000 ppb or 1 ppm while summer concentrations are as low as 100 ppb. Figure 3 shows the seasonal H_2S emission rates for the same two barns over the same time period as figure 2 and reveals a fairly consistent rate (≈ 2 g H_2S/day/AU). There are spring and fall spikes, which are best explained by the spring and fall turnover of manure effluent that was stored in an adjacent outside storage basin and was used as recharge water in the barn's pull plug manure gutters. Daily emissions for both NH_3 and H_2S for both sow barns are given in figure 4 for a cold and a warm month. The variations in seasonal emissions rates (or the lack thereof) can be seen from the monthly emission results graphs (figure 4) nearly as well as from the graphs for the whole 15-month period (figures 2 and 3). The spikes during the spring and fall are the only items that cannot be picked up by the single month data vs. the 15-month data.

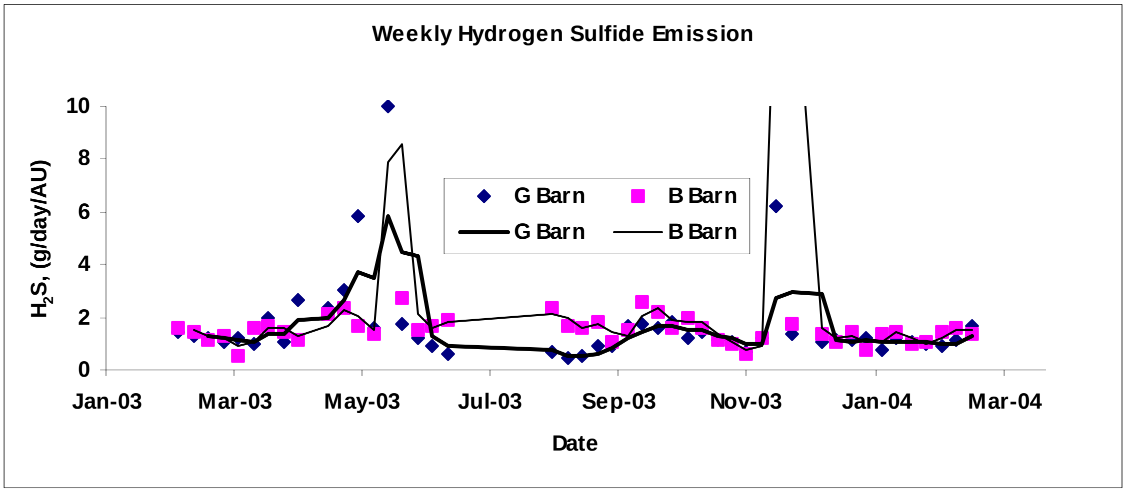


Figure 3. Weekly H_2S emissions over the 15-month period for MN breeding and gestation barns

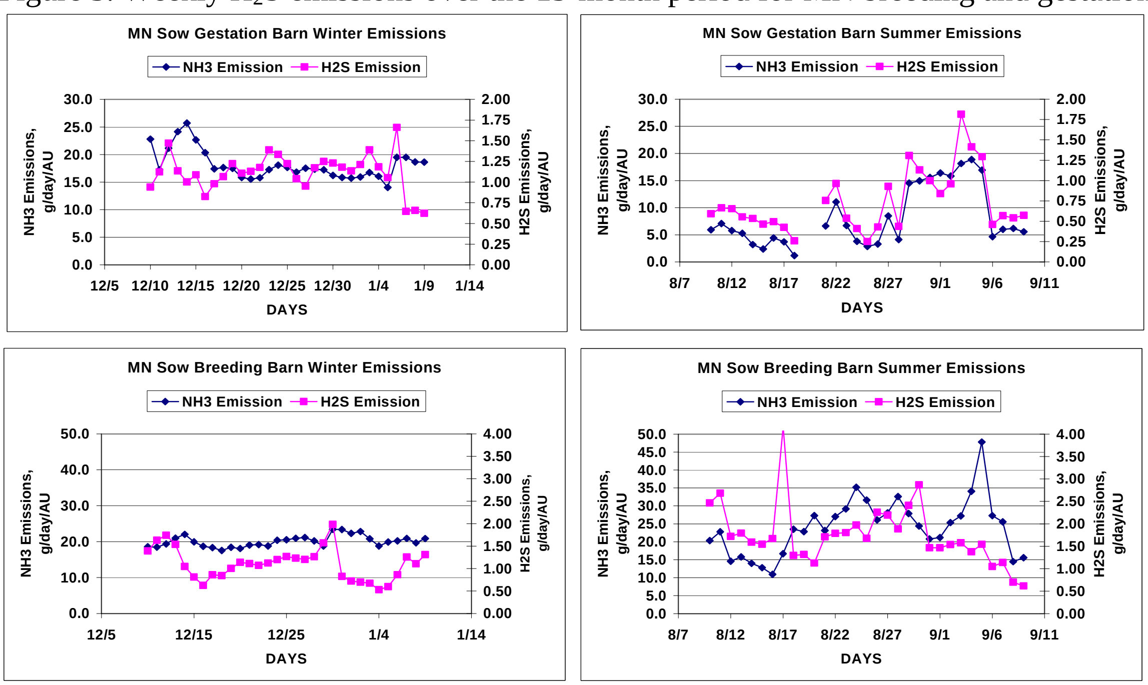


Figure 4. Daily NH_3 and H_2S emissions for the two MN dry sow barns (breeding and gestation) for a winter and a summer month

The weekly PM_{10} emission data for the15-month monitoring period in the two Minnesota dry sow barns is shown in figure 5. A slight seasonal effect may be present with less PM_{10} emitted in cold weather than during warm conditions. The same small seasonal effect is also apparent in the daily PM_{10} emissions for a cold and warm month (Figure 6). Both figures show greater variability in emission rates during warm conditions due probably to changing ventilation rates.

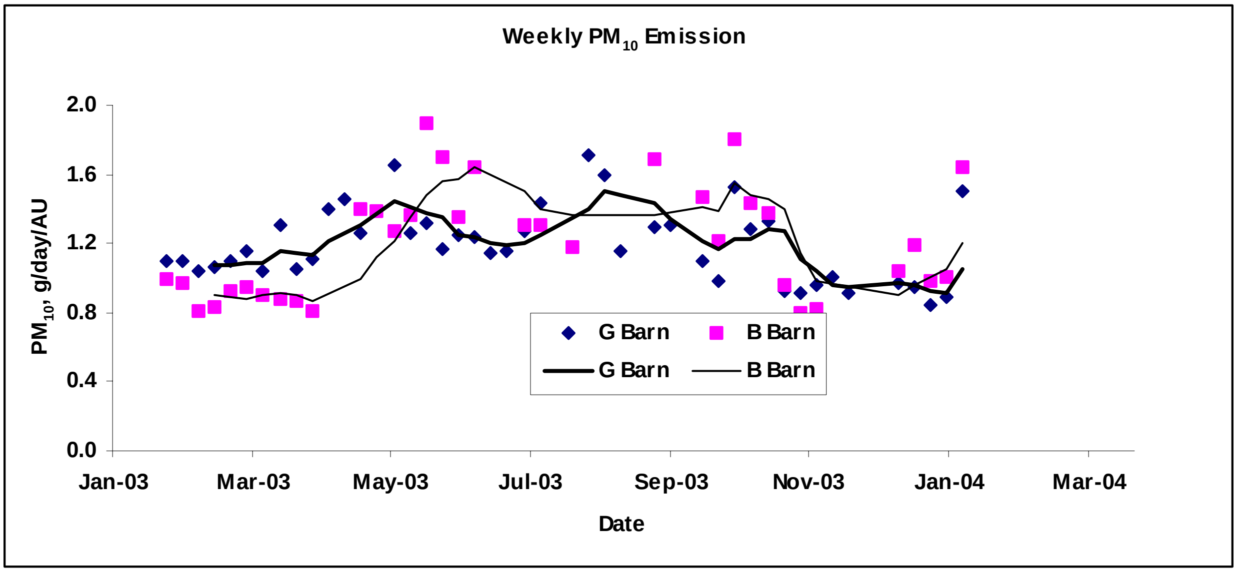
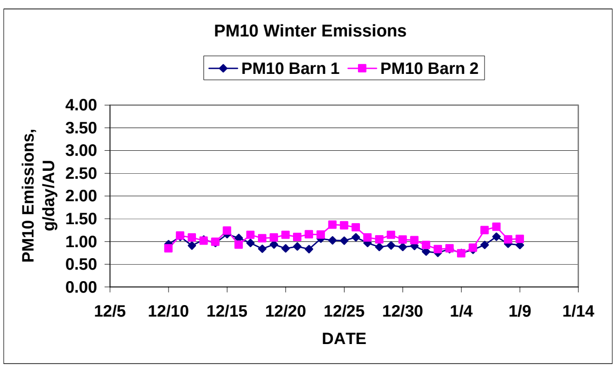


Figure 5. PM_{10} emissions over the 15-month period for the MN breeding and gestation barns



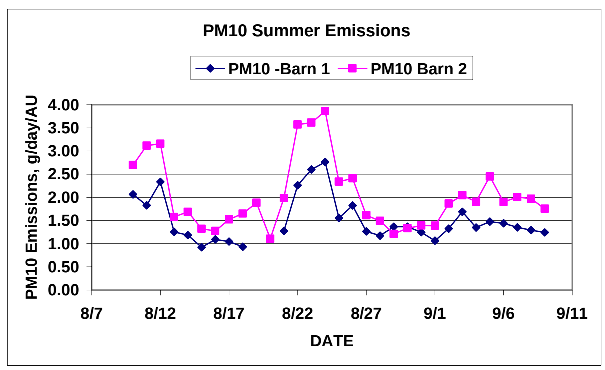


Figure 6. Daily PM_{10} emissions for the two sow barns (breeding and gestation) for a winter and a summer month

Summary and Conclusions

Ammonia (NH_3) emissions, when expressed on an animal unit (AU = 500 kg animal mass) basis from the Minnesota dry sow buildings measured during one cold and one warm month revealed very limited seasonal effects. The seasonal ventilation rates occurring in animal buildings seem to compensate for these seasonal NH_3 concentrations and result is a fairly constant ammonia emission rate. A similar trend is seen for hydrogen sulfide (H_2S) and PM_{10} emissions for the dry sow barns monitored in Minnesota.

All emission rates reported in this study (NH_3, H_2S, and PM_{10}) fluctuated more in the summer than in the winter probably because of more variability in ventilation rates. Also, some high acute emission events were found in the spring and fall which are probably explained by some unique manure management or animal practice event which although not routine or chronic in nature are real and need to be considered by producers when considering if they can meet both CERCLA and Clean Air Act regulations. None of the chronic emissions found from the MN sow barns would exceed either the 100 lbs per day CERCLA reporting threshold or the 100 tons per year Clean Air Act threshold. However, during the acute situations (spikes in emissions) some of the barns may reach 20 to 30 lbs of NH_3 emitted per day per barn and combined with other sources from that production sites (as required in a recent Circuit Court of Appeals case in Oklahoma; Feedstuffs, 2004) including other barns and associated manure storages the combined emissions might approach the 100 lb/day threshold. Thus even with a full month or two of data, one may miss an acute emission event if you are not aware of a particular manure or animal management practice in your housing systems that could cause such an event. Knowledge of these acute emission events can only be found by measuring for a full year, which allows these spikes or unusual events to be documented. A strategic emission measurement plan of less than one yer may be employed to capture these special acute events if they are known and thus make a reasonable assessment of the emissions from an animal production building during both chronic and acute conditions.

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