Confined Animal Manure Managers Conference: CAMM 2016

January 14, 2016

Held in conjunction with the

Location: Santee Room, Florence Civic Center, Florence, SC

CLEMSON
COOPERATIVE EXTENSION

Welcome to CAMM 2016

Welcome to the first, biannual Confined Animal Manure Managers Conference. The idea for a conference similar to this one began several years ago as the CAMM program team was brainstorming about various ideas to provide recertification educational programs for poultry and livestock producers in South Carolina. As many of you know, we have been providing two-hour CAMM recertification classes in conjunction with the SC AgriBiz & Farm Expo every year since the Expo began. As attendance at the Expo has increased, it seemed like a natural fit to organize a conference for animal producers where they can obtain recertification credits, and also learn about new technologies by visiting with equipment vendors and service providers.

The CAMM Conference will be held every other year with the following objectives:

1. To provide educational seminars related to animal manure management by top experts in their fields, and
2. To provide a minimum of five recertification credits per conference.

We will continue to provide our normal CAMM recertification classes during odd years. But every even year the CAMM Conference will provide unique educational opportunities that will also provide five of the ten recertification credits required every five years to maintain SCDHEC animal manure permits.

We are glad you chose to attend CAMM 2106.

Sincerely,

The CAMM 2016 Conference Planning Committee

John P. Chastain, Ph.D., Professor and Extension Agricultural Engineer

William “Bryan” Smith, Area Extension Agent - Agricultural Engineer

Lee Van Vlake, Area Livestock and Forages Agent

Confined Animal Manure Managers Conference: CAMM 2016

Held in conjunction with the SC AgriBiz & Farm Expo

Website: http://scagribiz.com/expo/

January 14, 2016

Agenda

9:00 AM: CAMM 2016 Registration & View Exhibits

10:00-10:10: Conference Welcome

10:10-10:20: Benefits of Using Animal Manure to Grow Crops for On-Farm Biodiesel Production
Dr. John Chastain, Clemson University

10:20 – 11:30: Post-Harvest Processing of Energy Crops for Biodiesel
C. David Thornton, Clemson University.

11:30: Lunch instructions

11:40 – 1:30: Lunch, Visit Biodiesel Demonstration, and View Exhibits (Voucher provided for lunch as part of registration).

1:30 – 2:30: Research Update from USDA-ARS

Improved solid-liquid separation using polymers in flushing systems and new technology to recover the ammonia from covered lagoons
Dr. Matias Vanotti, Coastal Plains Soil, Water and Plant Research Center, Florence, SC.

Livestock waste-to-energy opportunities
Dr. Kyoung Ro, Coastal Plains Soil, Water and Plant Research Center, Florence, SC.

2:30 –3:30 PM: Dissipation of Emissions from Animal Production Facilities
Dr. John Worley, University of Georgia.

3:30 – 4:00: Break with Snacks

4:00-5:00: Air Pollutants Associated with Swine Farms: Their Impacts and Mitigation
Dr. Sanjay Shah, North Carolina State University.

5:00 – 5:10: Wrap up and ajourn.

Total CAMM Recertification Hours = 5.

Benefits of Using Animal Manure to Grow Crops for On-Farm Biodiesel Production

John P. Chastain, Ph.D., Professor and Extension Agricultural Engineer
Clemson University

A review of the literature indicated that good quality biodiesel can be used in farm equipment at concentrations from 20% (B20) to 100% (B100) depending on air temperature and the design of the engine. Using biodiesel reduces emissions of carbon monoxide, sulfur containing pollutants that contribute to acid rain, unburned hydrocarbons, and particulates. Using B100 in a diesel engine can reduce fuel efficiency by about 8%, but had no other negative impacts when operated during warm weather. Using B20 to B50 has been shown to be sufficient to make loss of fuel efficiency inconsequential and allows operation of tractors in cold weather. The objectives of this study were to compare the use of soybeans and canola as a fuel crop for on-farm biodiesel production, and to determine the benefits of using aninal manure as a source of fertilizer for on-farm fuel crop production.

Soybeans and canola are both oil seeds that can be used to make high-quality biodiesel. Soybeans are 19% oil and a single bushel will yield about 1.5 gallons of biodiesel. At a market price of $10 to $14 per bushel the soybean cost to produce a gallon of biodiesel can range from $6.67 to $9.33 per gallon. Or to state it another way, if the price of diesel is $4.20/gal making biodiesl on-farm would be like selling soybeans for only $6.30/bu. It was concluded that it would best to sell soybeans rather than use them for on-farm biodiesel production. Canola, or rape seed, contains 40% oil and will yield about 2.8 gal of biodiesel/bu. In the last few years, canola prices have ranged from $5/bu to $10/bu. At a diesel price of $4.20/gal the value of the canola would be $11.76/bu which exceeds traditional prices of canola and is slightly higher than recent US prices. Therefore, canola was selected as the preferred crop for on-farm production of biodiesel in this study.

Few canola buying stations are located in the Southeastern US, and as a result canola is typically not grown in swine and poultry producing states such as South Carolina, North Carolina, and Georgia. Canola can be grown in the fall and winter months in a manner similar to wheat which adds to the appeal of using canola for on-farm biodiesel production in southern states.

A crop budget for canola production in the Southeastern US was used with current fertilizer prices to compare the cost to produce canola using purchased fertilizer versus using animal manure to provide all of the N, P_2O_5, and K_2O needs. It was determined that the cost to produce a bushel of canola was about $6.24/bu if commercial fertilizer was used. However, using manure as the sole nutrient source lowered production costs to $3.47/bushel. The input cost to produce biodiesel from canola was determined to be

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A crop budget for canola production in the Southeastern US was used with current fertilizer prices (end of 2012) to compare the cost to produce canola using purchased fertilizer versus using animal manure to provide all of the N, P_2O_5, and K_2O needs (Figure 1). It was determined that the cost to produce a bushel of canola was about $6.24/bu if commercial fertilizer was used. However, using manure as the sole nutrient source lowered production costs to $3.47/bushel. The input cost to produce biodiesel from canola was determined to be $2.23 per gallon if fertilizer was purchased versus $1.24 per gallon if manure was used to produce canola (Figure 2).

Cost to produce canola with and without animal manure - $/acre

	Fert.	Manure
Seed	$20.00	$20.00
N	$85.20	--
P2O5	$24.40	--
K2O	$33.00	--
Lime, Pest, Herb, Fung.	$57.25	$57.25
All Labor & Mach.	$81.00	$81.00
Interest on Op. Cap.	$11.29	$11.29
Total VC	$312.14	$173.54
Cost Per Bu (50 bu/ac)	$6.24	$3.47

Figure 1. Comparison of canola productions costs with and without using animal manure.

What is the canola cost per gallon of BD?

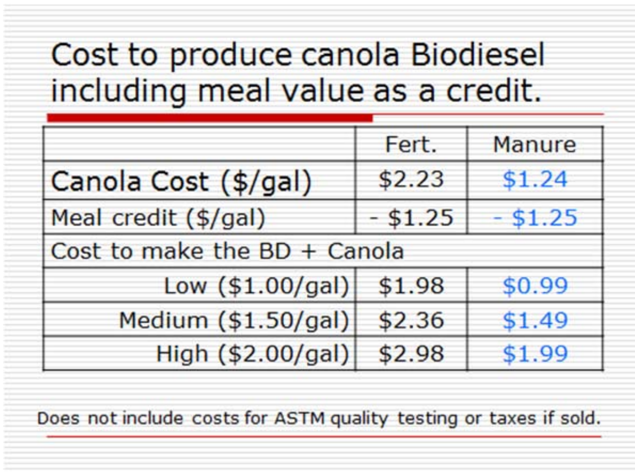
- Get 2.8 gal BD/bu of canola
- With purchased fertilizer canola cost is $2.23/gal biodiesel.
- If animal manure is used as sole fertilizer canola cost is $1.24/gal biodiesel.
- Using manure reduces canola cost by 44.4%.

Figure 2. Estimates of cost to produce canola per gallon of biodiesel.

Canola meal is a valuable by-product with a protein content of about 33% (extracted by pressing without solvents), and can be used as a protein source in animal feeds. The value of the canola meal was assumed to be $234/ton and the meal production per acre was 0.75 tons. The value of canola meal was determined to be $1.25 per gallon biodiesel. The value of the meal was used as a production credit towards the cost of making biodiesel on-farm

(Figure 3). This meal credit can only be realized if the meal is sold at market value or by using canola meal on-farm as a feed ingredient for livestock (e.g. beef or dairy cattle).

Using a moderate biodiesel production cost ($1.50/gal) the cost to make canola biodiesel on farm was $2.36/gal if fertilizer was purchased and $1.49/gal if manure was used as a fertilizer replacement. If the canola meal credit cannot be realized, on-farm biodiesel production cost was $3.61/gal if fertilizer was purchased and $2.74/gal if manure was used.


Cost to produce canola Biodiesel including meal value as a credit.

	Fert.	Manure
Canola Cost ($/gal)	$2.23	$1.24
Meal credit ($/gal)	- $1.25	- $1.25
Cost to make the BD + Canola		
Low ($1.00/gal)	$1.98	$0.99
Medium ($1.50/gal)	$2.36	$1.49
High ($2.00/gal)	$2.98	$1.99

Does not include costs for ASTM quality testing or taxes if sold.

Figure 3. Comparison of net cost of canola biodiesel after application of meal credit.

The number of acres of canola needed depends on the average yield and farm needs. The number of acres needed to produce 1000 gal of biodiesel per year ranges from 6 to 10 as shown in Figure 4.

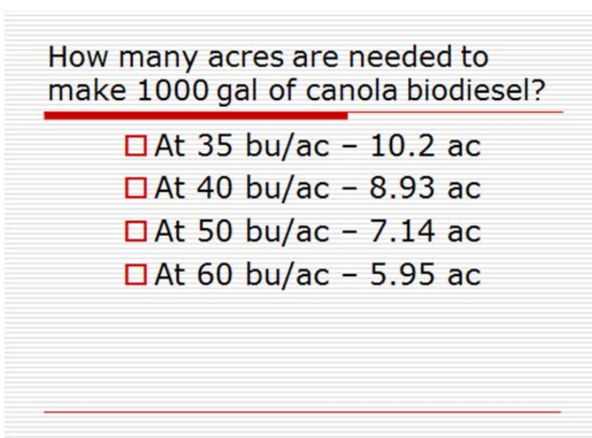


Figure 4. Estimate of acres needed to produce 1000 gallons on canola biodiesel based on average yield.

The results indicated that:

(1) soybeans are too valuable to be used as a fuel crop,

(2) canola can yield more fuel per acre than soybeans,

(3) fertilizer costs can account for 44% of the cost of producing canola,

(4) animal producers have a substantial advantage since manure can be used as a source of plant nutrients for canola,

(5) obtaining fair market value for canola meal is an essential part of lowering the cost to produce biodiesel, and

(6) making biodiesel for on-farm use or in a cooperative arrangement in a farming community appears to hold an opportunity for animal producers.

Speaker Biography

Dr. Chastain has been a faculty member at Clemson University since August 1995. Where his extension and research responsibilities include: animal waste collection and storage systems, land application of animal wastes and municipal sludge, alternative uses of waste, bioenergy from waste, odor control from animal production units, planning of animal production systems to protect surface and ground water quality, improving energy efficiency, use of alternative energy, and general livestock facility design.

Post-Harvest Processing of Energy Crops for Biodiesel

C. David Thornton, Biofuels and Organic Waste Project Coordinator, Clemson University

David Thornton will lead us through post-harvest processing of oil crops including seed cleaning, oil expulsion and oil quality analysis. Then learn about the process to convert these oils into clean-burning, domestically produced, renewable biodiesel as well as options for biodiesel production systems at various scales. Most importantly, Thornton will discuss essential biodiesel fuel quality control and important handling and use guidelines for this renewable fuel.

Speaker Biography

David Thornton is a bioprocess designer with 11 years of experience in biofuels facility design and co-product processing. Thornton constructed 26 biodiesel and ethanol facilities worldwide during his time as head of Piedmont Biofuels Design-Build division and has launched a handful of brewery related businesses providing essential brewing ingredients and services to breweries in the southeast. Additionally Thornton coordinates the sustainable biofuels program at Clemson University, and has taught the science of beer for 3 years. Thornton currently mentors graduate and undergraduate researchers at Clemson University in Biosystems Engineering and is a full time employee of Clemson University Facilities with the position of Organics and Biofuels Project Coordinator. He oversees the diversion of organic wastes from landfills and incorporates student participation in producing value added products for the University including biodiesel fuel, organic compost, sustainable animal feed and renewable synthesis gas.

USDA-ARS Research Update: Improved Solid-Liquid Separation Using Polymers in Flushing Systems and New Technology to Recover The Ammonia from Covered Lagoons.

Matias Vanotti, Ph.D., Research Scientist
Collaborators: Patrick Dube, Ariel Szogi, & Patrick Hunt
USDA-ARS, Coastal Plains Soil, Water and Plant Research Center, 2611 W. Lucas St., Florence, SC

Improved method for recovery of organic solids from diluted swine manure

Solid-liquid separation of the raw manure increases the capacity of decision making and opportunities for treatment. The high-rate separation up-front using flocculants allows recovery of most of the organic compounds, which can be used for manufacture of high-quality compost materials. However, the use of flocculants and dewatering equipment is costly on high-volume, diluted wastewater. Before this research was done, the use of flocculants and dewatering equipment was not effective in swine operations that use flushing systems and produce much diluted wastewater (< 0.5% solids). Scientists at ARS-Florence, South Carolina, in cooperation with industry, conducted on-farm research to determine at full-scale if rapid settling in a decanting tank can be used to concentrate solids in flushing systems and reduce the manure volume to be treated with flocculants and dewatering presses. Subsequently, the ammonia nitrogen in the liquid was treated with nitrifying bacteria adapted to high-strength wastewater and cold temperatures, and the treated water reused for flush tank recharge. The harvested manure solids were composted in a centralized facility and converted into value added commercial products. This innovation was successful: it increased polymer use efficiency 5.4 times (from 52 to 279 lb/lb) and reduced chemical expenses by 81%. It also reduced the manure volume processed by the separator press by 26,000 gallons per day (95% reduction) that significantly reduced size of the dewatering equipment. This lower volume is one of the major advances of the third generation project: It increased solid separator press capacity and lowered operating expenses when adapted to flushing systems.

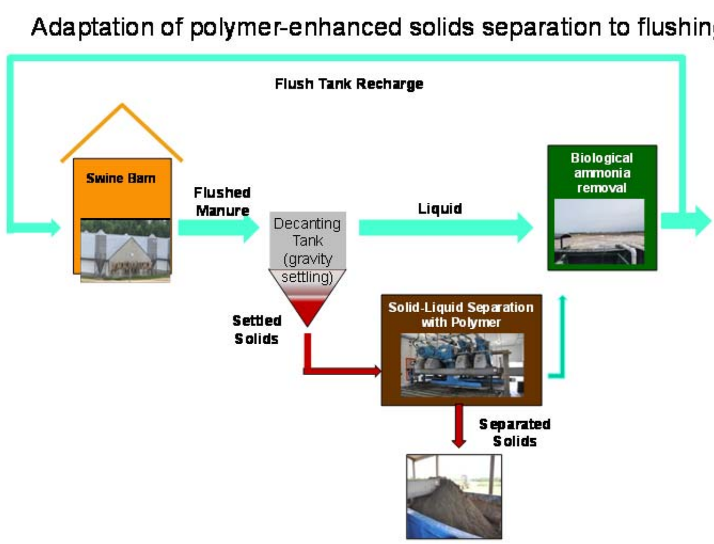


Figure 1. Adaptation of polymer-enhanced solids separation to flushing systems.

Enhanced recovery of ammonia from swine manure through gas membranes

Ammonia emissions from animal husbandry operations in the USA were estimated at 2.4 million tons/year in 2010, and the costs of fertilizers have rapidly increased in recent years, especially nitrogen fertilizer such as anhydrous ammonia which is made from natural gas. ARS researchers at Florence, SC have developed a new technology to recover concentrated ammonia from liquid manures. A US patent was awarded in 2015 (US 9,005,333 B1). The new technology uses gas-permeable membranes at low pressure that are submerged in the manure liquid. Low-rate aeration replaces alkali chemicals to raise the pH and enhance nitrogen recovery. The low-rate aeration reacted with the natural carbonates in wastewater and increased pH, which accelerated NH_3 uptake in the gas-permeable membrane system without the use of alkali chemicals. The new strategy worked quite well with swine manures. Digested effluents from covered anaerobic swine lagoons containing 1375 to 2089 ppm NH_4^+-N were treated using the submerged membranes, low-rate aeration and a small amount of nitrification inhibitor (22 ppm). Ammonia recovery of anaerobically digested swine wastewater using gas-permeable membranes was enhanced using the low-rate aeration. The low-rate aeration reacted with the natural carbonates in wastewater and increased pH, which accelerated NH_3 uptake by the gas-permeable membrane system without the use of alkali chemicals. The pH of the manure with aeration rose from 8.6 to 9.2 while the manure without aeration decreased from 8.6 to 8.1. Utilizing aeration, more than 96% of NH_4^+ was able to be recovered in about 4 days of operation. In contrast, without aeration it took 25 days to treat the NH_4^+. Completing NH_4^+ removal more than 5 times faster using gas-permeable membranes represented a 70% reduction in costs. This new system is expected to offer livestock producers a better way to manage ammonia in manure.

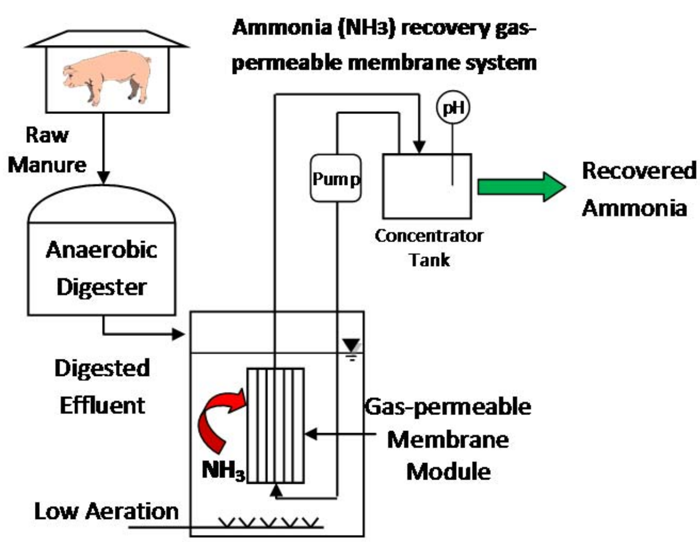


Figure 2. Using ammonia recovery with a gas-permeable membrane.

References

1. Vanotti, M., Hunt, P., Rice, M., Kunz, A., Loughrin, J., Williams, M. 2014. Generation 3 Treatment Technology for Diluted Swine Wastewater using High-Rate Solid-Liquid Separation and Nutrient Removal Processes. ASABE Meeting Paper 141901300 Avaibale at: https://www.ars.usda.gov/SP2UserFiles/Place/60820500/Patents_presentations_papers/ASABE_paper_141901300.pdf

2. Dube, P., Vanotti, M., Szogi, A. 2015. Enhanced recovery of ammonia from swine manure anaerobic digester effluent using gas-permeable membranes and aeration. ASABE Meeting Presentation DOI: 10.13031/aim.20152187787; Paper Number: 152187787.

Speaker Biography

Dr. Vanotti received an Agricultural Engineering degree from University of Buenos Aires, Argentina, and M.S. and Ph.D. degrees in Soil Science from University of Wisconsin-Madison. Since 1995, he has worked with the USDA-ARS Research Center in Florence, South Carolina on solving agricultural waste management problems. His research has focused on development of new treatment processes and systems for livestock manure including liquid-solid separation, nitrification/denitrification, anammox, phosphorus recovery and nitrogen recovery processes. Dr. Vanotti has produced 196 scientific publications and 12 patents. He received the Federal Laboratory Consortium (FLC) National Award for Excellence in Technology Transfer, both in 2010 and 2015.

USDA-ARS Research Update: Livestock Waste-to-Energy Opportunities

Kyoung S. Ro, Ph.D., Research Environmental Engineer
USDA-ARS Coastal Plains Soil, Water & Plant Research Center, Florence, SC.

The use of animal manure and other organic-based livestock wastes as feedstocks for waste-to-energy production has the potential to convert the livestock waste treatment from a liability into a profit center that can generate annual revenues and diversify farm income. This presentation introduces two prominent livestock waste-to-energy technologies; anaerobic digestion (AD) and pyrolysis.

Biochemical and thermochemical platforms are the two basic platforms exist for converting organic biomass into energy. Biochemical conversion processes use living organisms or their products to convert organic material to fuels. AD is the most dominant waste-to-energy technology which produces combustible biogas. AD breaks down complex organic wastes and produces biogas, chiefly methane (60-70%) and carbon dioxide (30-40%), by a community of anaerobic microorganisms. Potential benefits of AD are odor control, potential pathogen kill, reduction of wastewater strength, preservation of plant nutrients for use as a high quality fertilizer, and production of a renewable energy source- biogas (Cantrell et al., 2008). The biogas can be used to meet on-farm heating needs or to meet electrical demands with the excess electricity having the potential to be sold to a local utility company. Unfortunately, in the case of farm-scale dairy manure anaerobic digestion, the energy savings and potential revenue (i.e., current selling price of electricity) were mostly not enough to provide a positive cash-flow (Wright et al., 2004).

Contrasting to slow biological-based conversion processes requiring an extended amount of reaction time (days, weeks or even months), thermochemical conversion processes (TCC) can quickly (seconds to hours) convert livestock wastes into combustible gas and value-added products. Pyrolysis is one of main TCC processes for converting livestock wastes-to-energy, which breaks down chemical bonds of biomass feedstock with heat in the absence of air. The end product of biomass pyrolysis is some combinations of combustible gas, oil, and carbonaceous solids called biochar. Biochar could be used as a soil amendment to improve soil quality. The distribution of the end products depends on the operating temperature, pressure, heating rate, and residence time. When swine manure, chicken litter, and a mixture of swine manure with ryegrass were pyrolyzed, swine manure produced gas with the highest heating value followed by the mixture of swine manure with rye grass and chicken litter (Ro et al., 2010). Biochar yield ranged from 43 to 49% based on dry weight with about 53% of carbon recovery. While the heating value of the chicken litter biochar was slightly below that of low rank coals, swine manure based biochars had heating values between high and low rank coals. Approximately 50% of the feedstock energy was retained in biochar and 25% in produced gases. Manure-based biochars contained higher concentrations of phosphorus (P) and potassium (K) than that of original manure feedstocks. Consequently these could be used as a low-grade fertilizer to improve soil fertility and crop yields. Extremely high energy (232.3 million Joules per kilogram, MJ/kg) was required to make 1 kg of biochar from wet swine manure with 97% moisture content (MC), making the process energetically not sustainable. Dewatered swine manure with 75% MC required substantially lower external energy by 19 folds. However, the pyrolysis process with dewatered swine manure was still energetically unsustainable.

Co-pyrolyzing swine manure with high energy density spent plastic mulch (SPM) film eliminated the need for external energy (Ro et al., 2014). The heating value of the product gas from the co-pyrolysis was found to be much higher than that of natural gas; furthermore, the gas had no detectable toxic fumigants. Energetically sustainable swine manure pyrolysis could be achieved by co-pyrolyzing dewatered swine manure with just 10% SPM. If more than 10% SPM is used, the co-pyrolysis would generate surplus energy which could be used for power generation. Biochars produced from the co-pyrolysis were similar to that from pyrolyzing swine manure alone in terms of surface area and surface chemical functionalities. The results of this study demonstrated the potential of using pyrolysis technology to manage two prominent agricultural waste streams (plastic mulch film wastes and swine manure) while producing value-added biochar and a power source that could be used for local farm operations.

References

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2. Ro, K.S., Cantrell, K.B., Hunt, P.G. 2010. High-temperature pyrolysis of blended animal manures for producing renewable energy and value-added biochar. *Ind. Eng. Chem. Res.*, **49**, 10125-10131.
3. Ro, K.S., Hunt, P.G., Jackson, M.A., Compton, D.L., Yates, S.R., Cantrell, K., Chang, S.C. 2014. Co-pyrolysis of swine manure with agricultural plastic waste: laboratory-scale study. *Waste Management*, **34**, 1520-1528.
4. Wright, P., Inglis, C., Ma, J., Gooch, C., B., A., Meister, A., Scott, N. 2004. Preliminary comparison of five anaerobic digestion systems on dairy farms in New Yok Sate. *American Society of Agricultural Engineers*, Ottawa, Ontario, Canada. ASABE. pp. 1-19.

Speaker Biography

Dr. Ro holds a Ph.D. in environmental engineering and is a research scientist for USDA-ARS. His current research focuses on agricultural waste treatment to energy and development of manure treatment/handling systems that improve soil health and water quality while minimizing odor, greenhouse gases, and ammonia.

Monitoring of Ammonia and Fine Particulates Downwind of Broiler Houses

John W. Worley, Ph.D., Professor and Extension Engineer, University of Georgia,
J. Phil Campbell Research and Education Center, Watkinsville, GA.,
Collaborators: Michael Czarick[1], Brian D. Fairchild[1], Casey W. Ritz[1], Lowry A. Harper[1],
Benjamin D. Hale[2], Luke P Naeher[2]
[1]Poultry Science Dept., University of Georgia, [2] Env. Health Science Dept., University of Georgia

Air emissions from animal feeding operations have become a growing concern for producers and their neighbors. Much work has been done to quantify emission rates; however, little information has been provided about air quality downwind from these facilities. This study investigates ammonia (NH_3) and PM2.5 (particulate matter ≤ 2.5 um in diameter) levels as they dissipate from the exhaust fans of selected commercial, tunnel-ventilated, broiler houses in Northeast Georgia.

The study was conducted on a four-house commercial broiler farm in Northeast Georgia, from July 18 through August 12, 2007. The 40 X 500-ft tunnel-ventilated, dropped-ceiling houses were orientated east to west with approximately 1,000-ft of open pasture located on the east end of the houses. The litter in the houses had been in place for two flocks. The farm manager operated the houses according to standard industry practices.

The layout of the houses and the instrumented area is shown in Figure 1.

Two weather stations were paced near the houses to monitor temperature, relative humidity, wind speed, and wind direction. Additional climate information on the general climatic wind conditions was taken about 300 ft from the houses in an open area without interference by the housing or other obstacles using a sonic anemometer.

Exterior ammonia concentrations were measured using open-path lasers (OPL's.) These instruments measure average concentrations on a line from the laser instrument to a reflector. The locations of the lasers are shown in Figure 1 and referenced throughout the paper as stations L100, L200, L300, and L500.

PM2.5 was measured in real time using Dustrak aerosol monitors and from a time-integrated basis using cyclone samplers.

Measurements were taken during the last 4 weeks of an 8-week grow-out. There were periods throughout the study where NH_3 and/or PM2.5 measurements could not be collected at one or more of the instrument locations primarily due to rain, condensation on the reflectors, and/or foggy conditions. Since one of the primary objectives of the study was to determine how concentrations varied with distance from the poultry houses, any 15-minute period that did not have a data point at each of the three distances was not included for analysis. Also, in order to more accurately represent daily average concentrations, study days that did not have at least two-thirds (67%) of the data present (NH_3 or PM) were not used.

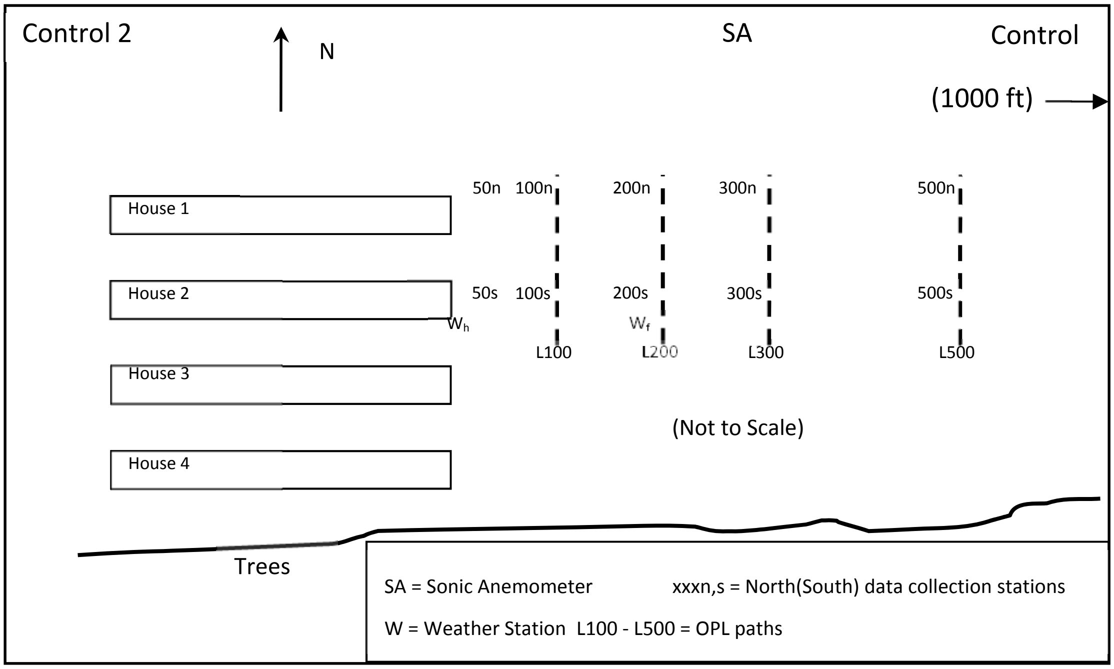

Figure. 1. Farm Layout and data collection sites (not to scale)

Results - Ammonia

As one might expect, the highest NH_3 concentrations during both study periods were found at station L100 (the station closest to the houses), and concentrations decreased with distance from the houses. Mean NH_3 concentrations during both study periods were below 0.6 ppm for all locations measured. The highest 15-minute reading during the entire study for each distance was 2.9, 2.9, 2.5, and 1.6 ppm for stations L100, L200, L300, and L500 respectively. Note that the NH_3 odor threshold limit given by the EPA ranges from 5 to 50 ppm (depending on individuals).

Wind Direction: As anticipated, downwind NH_3 concentrations were found to be greatest when the predominant wind direction was from the houses towards the measurement locations (Azimuths between 190 and 300, Figure 2). The effect of wind direction on downwind NH_3 concentrations was most notable at distances greater than 100 ft from the tunnel fans. This apparent reduced-influence of wind direction at station L100 was primarily due to the fact that the tunnel fans produced a low but measurable wind velocity at that station, thus tending to overpower the effect of ambient wind direction, especially at low wind velocities which were often encountered during the study.

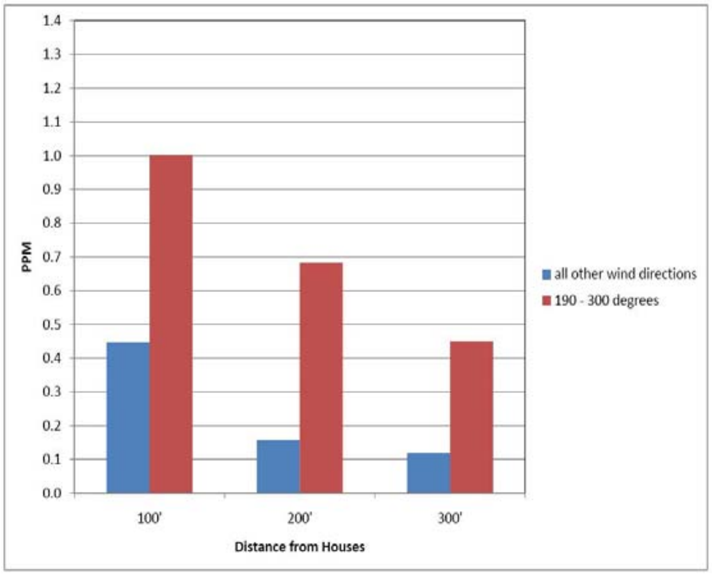

Figure 2. Ammonia Concentration vs. wind direction (week five through seven)

Wind Speed: The highest downwind NH_3 concentrations generally occurred when wind speeds were less than 2 mph. Figure 3 shows downwind NH_3 concentrations at all laser locations as a function of wind speed when the predominant wind was blowing from an azimuth between 190 and 300^o as measured by the met station. The higher wind speeds would likely result in a greater mixing of the exhaust air from the poultry house with the surrounding air, resulting in lower NH_3 concentrations downwind.

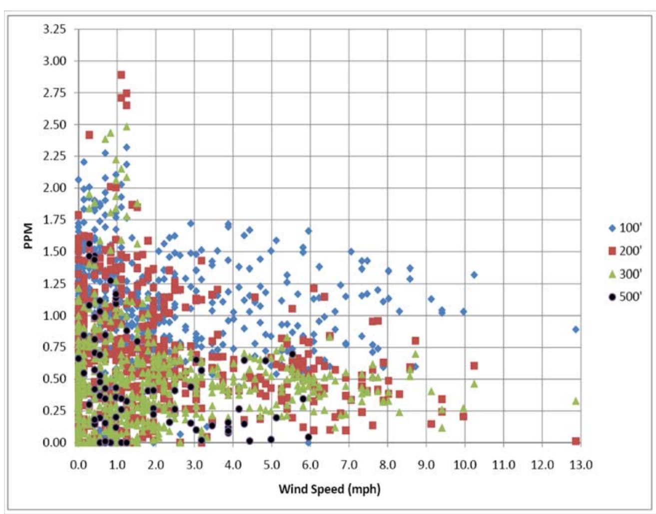

Figure 3. Ammonia Concentration vs. Wind Speed (when wind direction was between 190 and 300^o)

Time of Day: The average daytime (7 am to 5 pm) and nighttime (6 pm to 6 am) NH_3 concentrations for both study periods are illustrated in Figure 4. Concentrations tended to be approximately twice as high at night as during the day for distances from the poultry houses at stations L200 and further from the houses.

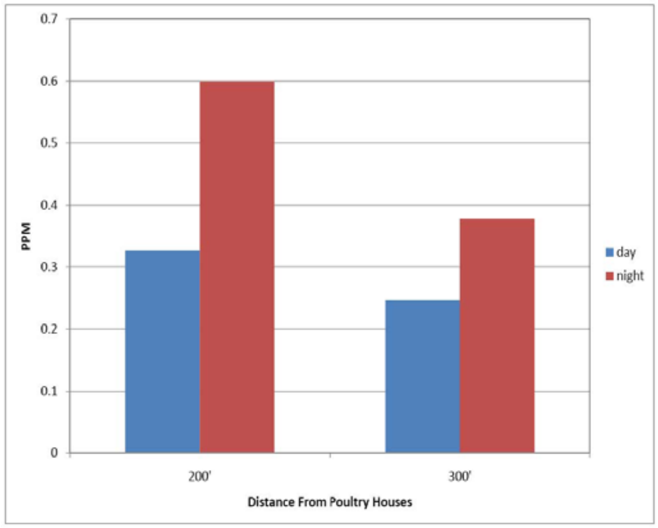

Figure 4. Effect of Day vs. Night on Ammonia Concentration (weeks five through seven)

Results - Particulate Matter

Figure 5 shows daily average PM 2.5 data for all stations and dates which met the availability criteria. Also included is data taken at a site in Athens, GA. The site was approximately 20 miles away from the farm and was used to compare to what might be considered “background readings.” The pm data measured during the experiment closely mimic what was observed in Athens indicating that background PM levels had a very large influence on the results of the study.

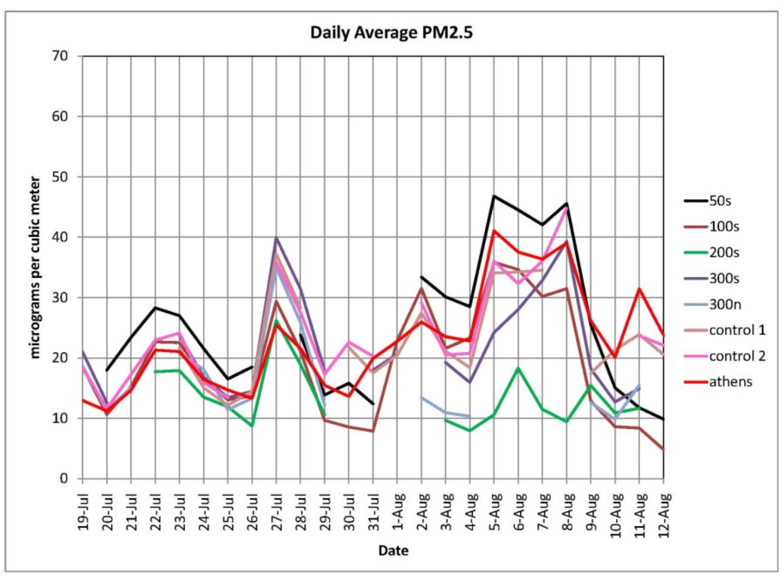

Figure 5. Daily Average PM 2.5 data

Some relationship between PM levels and distance from the houses was apparent with the highest readings measured at 50 ft from the house. The highest daily averages observed were in the range of 30 to 45 µg/m^3.

These observations were during periods of highest background conditions and when the winds were generally from the direction of the houses. Note that on the same days these readings were taken, the Athens station recorded levels of approximately 40 μg/m^3. (EPA 24-hr ambient air standard is 35.)

Summary

Results indicate a rapid dissipation of both ammonia and fine particulates as the distance from the source increases. When compared to nearby monitoring data, particulate levels appear to be near background levels. Ammonia levels are higher when wind is blowing from the source toward the sensors and tend to be higher when wind speed is less than 3.2 km/h (2 mph.) At low wind speeds, air movement created by fans overpowers ambient wind at the 30-m distance.

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Speaker Biography

Dr. Worley is Professor with the Department of Poultry Science at the University of Georgia. He received his B.S. in Agricultural Engineering from the University of Georgia in 1973 and worked for Gold Kist, Inc. for nine years before returning to school and earning his M.S. from UGA and his Ph.D from Virginia Tech, both in Agricultural Engineering. He taught in the engineering program at UGA for eight years before joining Cooperative Extension in 1995. He specializes in agricultural structures, animal waste management, energy conservation, rural air quality, and electrical applications. He was the 2013 recipient of the Walter Bernard Hill Award for Outstanding Achievement in Public Service which is considered the highest honor available in Outreach at the University of Georgia.

Air Pollutants Associated with Swine Farms: Their Impacts and Mitigation

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Air pollutants of concern from swine farms

Swine farms are associated with six types of air pollutants, namely, ammonia, hydrogen sulfide, greenhouse gases, volatile organic compounds (VOCs), particulate matter (PM) or dust, and odor. Odor is caused by the release of ammonia, hydrogen sulfide, and VOCs, or their combination. In terms of amount emitted from swine farms and its adverse impacts, ammonia is perhaps the most important gas of concern. Ammonia, which has a pungent odor, forms due to the microbial degradation of urine, feces, and feed in the waste. Ammonia contributes to the formation of very fine PM which can affect human health and also contributes to haze. In terms of its environmental impacts, when ammonia released into the air returns to the ground or water bodies, it can cause soil acidification or excessive algal growth in water bodies, diminishing the productivities of these natural resources. Ammonia concentrations in excess of 25 ppm inside swine houses can also reduce swine performance. Ammonia loss from swine waste also reduces its fertilizer value. The EPA estimated that more than 70% of US ammonia emissions came from livestock with about a fifth of the livestock emissions coming from swine barns, storage and treatment systems, and during land application of swine waste. Hence, at the national scale, ammonia is the most important pollutant of concern emitted from swine barns.

Hydrogen sulfide is formed when microbes break down organic and inorganic sulfur compounds in the absence of oxygen. Hydrogen sulfide has a very strong odor and also contributes to acid rain. However, compared with deep pit systems commonly used in the Midwest, hydrogen sulfide levels are much lower in shallow pit barns common in the South or Southeast. Compared to other sources (e.g., natural gas production) of hydrogen sulfide emissions, livestock agriculture is a minor source.

The two most important greenhouse gases associated with livestock production are methane and nitrous oxide. While an estimated 9% of greenhouse gas emissions are attributable to agriculture, compared with dairy or beef cattle, swine production contributes very little. Volatile organic compounds comprise more than 300 organic compounds that are in the gaseous form at room temperature; these compounds are usually formed in the waste due to lack of oxygen, i.e., usually in liquid waste. Several of these gases are highly odorous while others have undesirable health impacts; some VOCs also contribute to climate change while others contribute to PM formation. It is widely recognized that VOCs are a major source of swine odors. Compared to other sectors of the economy, emissions of VOCs from livestock farms are minor but they can cause major odor issues at the fence line.

Particulate matter emission from swine barns is due to entrainment and transport of dried fecal material, dander, and feed in ventilation air and also due to animal activity. Since PM can carry adsorbed gases, they are an important source of odor. Studies have shown that controlling PM emissions can also reduce odors. High PM concentrations inside the barn can degrade swine performance.

Odor is perhaps, the biggest source of concern to people living adjacent to swine farms as it affects quality-of-life, thereby, affecting property values. Particulate matter complaints are also received. Due to recent studies on the impacts of VOCs and hydrogen sulfide emissions on the mood and health of swine farm neighbors, of late, more concerns are being received about VOC emissions from swine farms.

The NRCS, in collaboration with several universities and commodity groups (e.g., National Pork Board) has developed the National Air Quality Site Assessment Tool (NAQSAT, http://naqsat.tamu.edu/) to reduce air emissions from confined livestock facilities. While NAQSAT cannot calculate emissions or provide regulatory guidance, using surveys, one can evaluate how an improved practice can reduce emissions of a particular pollutant relative to the current practice. This tool is quite comprehensive it its scope including various factors that impact emissions, e.g., diet, management, land application, etc.

Remediation methods

Barn: Compared with fully-slatted floors, partially-slatted floors accumulate more fecal material leading to increased ammonia and odor levels in the living area of the animals. Proper pen management can also impact indoor air quality as well as emissions. Some producers push the fecal material accumulating in the alleys back into the pens to let the pigs work the feces back into the pits; this may reduce ammonia levels in the living area of the pigs than if feces were to accumulate in the alleys.

Dietary manipulation, to match nutrient supply with requirement, can be effective in reducing emissions, particularly of ammonia. However, diets are formulated with the primary objective of ensuring profitability, not to reduce environmental impacts. Due to economics, dried distillers grains with solubles (DDGS) is being used to supplement the conventional corn-soybean meal; DDGS can reduce ammonia and hydrogen sulfide emissions compared with the conventional diet. Feed formulation and method of delivery can also reduce PM concentrations, and perhaps, emissions. Fat can be added to feed to reduce PM. Compared with mash or meal, pelleted feed can also reduce PM. Reducing the drop height of the feed and presenting feed in the wet form vs. dry form can also reduce PM.

Some additives can improve the barn air quality. In the Midwest, some producers sprinkle oil in pig pens to reduce PM concentrations; however, this practice can cause slippery surfaces. Research performed in Denmark showed that spraying dilute sulfuric acid solution in the pens reduced ammonia and PM levels in the barn which also improved pig performance. Improved air quality also benefited the workers. Spraying an acidic salt solution to waste in shallow pits has shown to reduce ammonia levels in the house. But care should be taken while spraying highly acidic solution on bare concrete or metal since acid can cause corrosion.

Some digestive additives containing beneficial microbes and enzymes, when added to the waste in pits, may reduce ammonia levels and even improve pig performance; some pit additives are also effective in breaking down solids to facilitate emptying of the pits. However, performance of digestive additives is not consistent, i.e., in some studies, they were effective while in other studies, they were not. Further, additives effective in lab studies may not be effective in commercial houses. While pit additives can be effective and can be incorporated into current management practices, compared with 10-15 years ago, use of pit additives seems to have decreased considerably.

There are some exhaust treatment technologies (e.g., biofiltration, acid scrubbing) used in the industry that can be used to reduce emissions from swine barns. However, these technologies are generally not compatible with the mechanical ventilation systems used in US swine barns and thus it would be very expensive to modify barns to incorporate these technologies. These exhaust treatment technologies are being used in some livestock barns in Europe where the barn's ventilation exhaust is duct through a plenum into the treatment system.

Windbreaks, comprised of suitable trees and shrubs placed downwind of ventilation fans could be effective in improving air quality, both, by facilitating dilution of exhaust air and by trapping pollutants (mostly PM). Windbreaks are more effective when they are placed close to fans; however, this can increase the maintenance requirements. Additionally, space requirements of the natural windbreaks can limit their adoption on many farms. Engineered windbreak walls, that can be placed closer to fans than natural windbreaks could be effective in trapping PM, thereby, reducing odors. However, more research on the effectiveness use of such engineered windbreak walls.

Treatment and storage: The anaerobic lagoon is the predominant waste treatment and storage method used in the Southeast. Proper loading of the lagoon will ensure that odor will not be an issue. As with barns, some lagoon additives can be effective in reducing emissions and reducing sludge levels. However, popularity of additives have declined compared with 10-15 years ago. Lagoon covers can be very effective in reducing odors but can be expensive. Incorporating a biogas digester with a covered lagoon can substantially reduce methane emission while also producing energy; however, economics is the main issue when considering methane generation given the low price of natural gas.

Some swine farms compost the solid waste fraction in their waste but because of NRCS support, swine mortality composting has become even more popular. Compared with a conventional incinerator, a properly-operated swine mortality composting operation not only saves money by reducing propane use but also reduces odors. However, there is need for more operator training to improve operation of swine mortality composting systems.

Land application: During land application, some of the ammonia and odor are emitted; these emissions can be made worse by drift of liquid droplets away from the land application site. Proper selection of land application equipment can be very effective in reducing emissions. For example, compared with the traveling gun, the drag hose system's ammonia losses are less than one-quarter; comparable reductions in odor can also be expected. Reduced ammonia losses with the drag hose system also results in more nitrogen available for plant growth. Weather conditions and time of day can also affect odor emissions during land application with sprinkler type application systems. Application early in the morning or under overcast conditions can reduce vertical odor dissipation and increase lateral transport of odor. Hence, when using sprinkler systems, applying under sunny conditions can reduce odors even though ammonia losses may be higher.

Summary

Because of the large amounts emitted from swine barns and its multiple effects on swine performance, public health, and environmental impacts, ammonia is the biggest pollutant of concern emitted from swine barns. However, due to its impact on quality of life, odor is the biggest pollutant of concern at the fence line. Reducing PM emissions from the barn can reduce odor and ammonia emissions. Air emissions from barns can be reduced through management and barn design; however, a suitable additive can effectively reduce emissions, particularly of ammonia, and may even improve swine performance. A natural windbreak can reduce emissions but requires space and management. There is need to evaluate the use of windbreak walls as they are more compatible with mechanical ventilation than natural windbreaks. Lagoon emissions can be reduced through proper loading as well as using additives or cover. While a covered lagoon is compatible with a biogas digester, economics needs to be considered. A well-managed swine mortality composting system can be less expensive and less odorous than a conventional incinerator. Compared with sprinkler-based waste application systems, such as the traveling gun, the drag hose system can reduce ammonia and odor emissions and conserve nitrogen. Waste application under sunny conditions can reduce odor emissions.

Speaker Biography

Dr. Shah was born in Nepal. He received his BS (Agric. Eng.) from India, MS from Louisiana State University, and PhD from Virginia Tech. Dr. Shah has been involved in teaching, extension, and research in the areas of agricultural air quality, structures and ventilation, and renewable energy use in livestock barns since 2003.