IOWA STATE UNIVERSITY
College of Agriculture and Life Sciences

Selected ISU Livestock Odor and Air Quality Research and Extension Activities
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Air Management Practices Assessment Tool. AMPAT is an online resource that provides an objective overview of mitigation practices best suited to address odor, emissions and dust at Iowa livestock operations. AMPAT helps producers compare and narrow their options of the best mitigation techniques for animal housing, manure storage and handling and land application of manure. The tool provides conservative estimates of the effectiveness of mitigation plus the relative cost. It was originally developed in 2004 and updated in 2014.

- Phase 1: Funded by the National Pork Board, this project updated the previous site to include more recent mitigation techniques and to add impacts on volatile organic compounds and greenhouse gases. A new interface for easier side-by-side comparisons is included. Short video presentations and fact sheets are available for each of 21 technologies. *(Jay Harmon, Steve Hoff, Dan Andersen, Agricultural & Biosystems Engineering; Angie Rieck-Hinz, Agronomy)*
- Phase 2: Funded by the Indiana Soybean Alliance (2013-2014), this project provided a comprehensive literature database for all major livestock and poultry species. This data is available for researchers and others wanting to examine mitigation techniques at a deeper level. Results are used to update and improve the AMPAT tool as new information emerges. *(Jacek Koziel, Jay Harmon, Steve Hoff, Agricultural & Biosystems Engineering; Angie Rieck-Hinz, Agronomy)*

ISU review published in 2016 finds majority of technologies aimed at reducing odor and gas emissions from livestock production never see field-scale testing. The review of hundreds of academic journal articles studying technologies to reduce odor and gaseous emissions from livestock and poultry operations shows that most such technologies undergo lab testing but never reach farm-scale study. The results of the literature review show the difficulty of scaling up new technologies to address gas and odor emissions in livestock production. Funded by the Indiana Soybean Alliance 2013-2014. *(Jacek Koziel, Jay Harmon, Steve Hoff, Devin Maurer, Daniel Andersen, Agricultural & Biosystems Engineering; Angie Rieck-Hinz, Agronomy)*

Evaluation of polymer to reduce emissions from swine finishing facilities. ISU scientists conducted research to evaluate the efficacy of an acidic polymer from a private firm to potentially reduce ammonia, greenhouse gas and odor emissions from deep-pit swine manure storage areas. The Specialty Fertilizer Products (Verdesian Life Sciences)-funded project (2014-2015), was initially a lab study under controlled conditions using manures of different sources and distinct dosing rates. *(Daniel Andersen, Jacek Koziel, Agricultural & Biosystems Engineering)*

Estimating methane emissions. ISU researchers developed a lab procedure to estimate manure's methane production rate and used field-measured variables to estimate methane emission from swine manure storage areas. They continue to work on methods to characterize manure's physical, chemical and biological properties and relate them to the methane production rate. The research is important to better understand and estimate the production and emission of this potent greenhouse gas

from manure storage. Funded by Iowa Pork Producers Association (2012-2015). *(Daniel Andersen, Agricultural & Biosystems Engineering)*

Anaerobic digestion's impact on odor, ammonia. ISU scientists are studying anaerobic digestion and energy generation from manure and how these processes may influence odor and ammonia emissions. They will evaluate how anaerobic digestion influences odor and ammonia during storage after digestion and undigested manure. They will evaluate physical properties including solids content, particle size distribution and viscosity as well as chemical properties including pH, ammonia nitrogen content, chemical oxygen demand and volatiles solids. They will seek to relate these properties to the potential for ammonia and odor emission. Student funded by Fulbright Scholar program (2016-2017). *(Daniel Andersen, Jacek Koziel, Agricultural & Biosystems Engineering)*

Diets that reduce ammonia emissions from hen houses (2010-2012). Results from ISU research indicate that manipulating the diets of laying hens is a viable means of reducing ammonia emissions. The two-year field study involving commercial laying-hen houses in Iowa examined the effects of adding to diets a commercial feed additive called EcoCal or dried distillers grains with solubles (DDGS). The research results have been published in peer-reviewed journals. The feed additive diet reduced ammonia emissions by an average of 39 percent; the DDGS diet reduced emissions by 14 percent. In both cases, the diets had no negative effects on hen production performance as compared to the control diet. The project was funded by the USDA Natural Resource Conservation Service's Conservation innovation Grant Program and the United Egg Producers. *(Hongwei Xin, Hong Li, Agricultural & Biosystems Engineering)*

Environmental assessment of laying-hen housing systems (2012-2015). ISU scientists have completed a field study to quantify indoor air quality and gas and particulate emissions as part of a national project that is systematically assessing three different laying-hen housing systems. Data from the study, which have been published in peer-reviewed journals, provide baseline comparisons and emission values for conventional and alternative hen-housing systems (enriched colony and aviary cage-free). The data obtained from this study filled the knowledge gaps on air emissions of certain hen housing systems. The study further revealed the environmental challenges (indoor air quality and air emissions) with the cage-free hen housing system. The project was funded by the Coalition for Sustainable Egg Supply. *(Hongwei Xin, Tim Shepherd, Yang Zhao, Agricultural & Biosystems Engineering)*

Improving indoor air quality and mitigating air emissions of cage-free hen houses (2015-present). Scientists have completed a series of lab-scale studies to explore practical means to mitigate the generation of dust, ammonia and airborne bacteria inherent in cage-free hen housing. A novel method has been tested to be effective in mitigating these pollutants simultaneously under the lab setting and is now undergoing field verification. The results prove very promising. The same system can be used to alleviate heat stress of the birds in summertime. Results from this project will have a major impact on the environmental stewardship of cage-free egg production, which has been gaining increasing attention in the U.S. The project was funded by a USDA-NIFA grant. *(Hongwei Xin, Lilong Chai, Michelle Soupir, Agricultural & Biosystems Engineering; Tong Wang, Food Science and Human Nutrition; Suzanne Millman, Veterinary Diagnostic & Production Animal Medicine)*

Development of ammonia emission estimation tool for egg production (2017). In response to the "anticipated" requirement of reporting ammonia emissions from animal production facilates, a set of user-friendly spreadsheet estimators on ammonia

emissions from various pullet and laying-hen production facilities were developed and distributed to the egg industry and government (EPA) stakeholders. The spreadsheet estimators are located on the EIC website: https://www.eggindustrycenter.org/research/latest-research/categories/80ebacb7ae1747bfb42f3e20f7874906 *(Hongwei Xin, Maro Ibarburu, Egg Industry Center)*

Quantifying emissions from swine facilities (2012-2014). A first-of-its-kind study by Iowa State has filled information gaps on air emissions from swine facilities. Research and information on ammonia and greenhouse gas emissions from swine operations — particularly from breeding, gestation and farrowing facilities in the Midwest — has been meager. A research team quantified ammonia and greenhouse gas emissions from a 4,300-sow breeding, gestation and farrowing facility located in central Iowa. The research contributes to establishing accurate baseline emission rates for similar facilities in the Midwest and provide farmers with reliable data in making decisions on emission controls. The project was funded by the Iowa Pork Producers Association and administered by the National Pork Board. *(Hongwei Xin, Robert Burns and John Stinn, Agricultural & Biosystems Engineering)*

Community Assessment Model (CAM) for odor dispersion. Since 2005, CAM has been a valuable preplanning tool offering guidance for hundreds of Iowa pork producers on where to build new facilities. The field-validated computer model helps assess potential site risk and determine how far odors from proposed sites will travel under a variety of atmospheric conditions. The model makes predictions based on historic weather patterns, type and size of facility and number of animals. CAM notes location of neighbors, other odor sources, number and age of animals, seasonal ventilation rates and more. The model estimates what percentage of time a neighbor may be exposed to odors. It factors in how odor-reduction technologies would benefit sites. ISU's Iowa Pork Industry Center and the Coalition to Support Farmers have partnered to advise farmers on selecting sites, including using CAM as a resource. Three papers on CAM's acceptance as a useful tool and evaluating its effectiveness have been published. Funding from Iowa Pork Producers and USDA. *(Steve Hoff, Jay Harmon, Agricultural & Biosystems Engineering)*

Biofilters to mitigate odors, emissions. Biofilters can be an effective means to reduce odor and other gas emissions from ventilated animal and manure storage facilities. Iowa State hosted a biofilter conference in 2014, to introduce producers, managers and owners to biofilters and how they may be used to mitigate emissions from animal-feeding operations. The conference outlined factors such as costs, effectiveness, management and other details, and provide sources of science-based information on biofilters. Funding from Iowa Pork Producers and USDA. *(Steve Hoff, Jay Harmon, Agricultural & Biosystems Engineering)*

Soybean-hull manure additive. Iowa State researchers conducted farm-scale testing of soybean peroxidase, a compound derived from soybean hulls for swine manure treatment and mitigation of key odor-causing gases, ammonia, hydrogen sulfide and greenhouse gas emissions. The researchers applied the ground soybean hulls-based product treatment through floor slats of swine housing. Over a month and a half, the treatment reduced ammonia by 22 percent, hydrogen sulfide by 80 percent and key odor-causing compounds from 14 percent to 48 percent. The estimated cost of treatment was $1.45 per marketed pig and $2.62 per marketed pig when the cost of labor was added, placing it at the lower range of comparable products. The project, funded by the National Pork Board (2012-2013), was published in 2017. *(Jacek Koziel, Agricultural & Biosystems Engineering)*

Biochar manure additive. Iowa State researchers conducted [pilot-scale testing](#) of biochar, a byproduct derived from cellulosic-based biofuels production for swine manure treatment and mitigation of key odor-causing gases, ammonia, hydrogen sulfide and greenhouse gas emissions. The researchers applied a thin layer of the biochar treatment on top of manure to simulate application through floor slats of swine housing. Over a month, the treatment reduced ammonia by 13 to 23 percent, while methane emissions increased by 22 to 25 percent. The estimated (extrapolated and scaled-up) cost of treatment was as low as $0.15 per marketed pig. The one-year project was partially supported by the Iowa Agriculture and Home Economics Experiment Station and was completed in 2016. *(Jacek Koziel, Agricultural & Biosystems Engineering)*

Wet-scrubber to mitigate particulate matter, odors, emissions. Iowa State and USDA-ARS researchers conducted collaborative testing of wet-scrubber technology for mitigation of particulate matter, odor, key odor-causing gases and ammonia emissions. The scrubber is operating on barn exhaust of a collaborating swine farm in northeast Iowa. The project was funded by Indiana Soybean Alliance (2015-2017). Preliminary data indicates that the system is reducing particulate matter by 66 to 95 percent. Reduction of ammonia ranged from 15 to 35 percent with overall odor reductions of 35 percent. Odor-causing volatile organic compounds were reduced from 50 to 70 percent. Guidance documents on construction and management of this system are being developed and footage for a virtual field day were obtained to perform extension and outreach based on this work. *(Jacek Koziel, Daniel Andersen, Jay Harmon, Steve Hoff, Agricultural & Biosystems Engineering; Steven Trabue, USDA-ARS-Ames; Mark Storlie, ISU Extension and Outreach)*

Black light used to mitigate odors, emissions. ISU researchers conducted [lab-scale testing](#) of black light for mitigation of key odor-causing gases and greenhouse gas emissions. Shining on surfaces coated with a thin layer of titanium dioxide, the black light initiates photocatalytic reactions that have been found to significantly reduce (from 40 to 100 percent) several odorous chemicals that are found downwind of livestock operations. Pilot-scale studies completed in 2017, decreased odor emissions by 16 percent while also reducing a key "signature" gas responsible for the characteristic downwind odor emissions by 22 percent. An unexpected result was a 9 percent reduction in nitrous oxide, a major greenhouse gas. The project was funded by Indiana Soybean Alliance (2015-2017). *(Jacek Koziel, Agricultural & Biosystems Engineering)*

Microbial and mineral adsorbent treatment for poultry manure odor. ISU scientists conducted research to evaluate the efficacy of a surface application of a microbial-mineral treatment of odor-causing phenolics and sulfur containing volatiles emitted from poultry manure. A microbial-mineral litter additive consisting of 20 percent of bacteria powder and 80 percent of perlite-bentonite was used. There was no significant difference between treatments consisting of microbial-mineral additive and mineral adsorbent alone. The 2016 project was funded the Iowa Agriculture and Home Economics Experiment Station, State of Iowa funds and by the Kosciuszko Foundation and [published in 2017](#). *(Jacek Koziel, Agricultural & Biosystems Engineering; Kajetan Kalus, visiting scientist from Wroclaw University of Environmental and Life Sciences, Poland)*

On-site odor measurement technology evaluated. ISU scientists conducted collaborative research to evaluate the performance of portable olfactometer. Portable olfactometers are a simpler version of the lab-based standardized technology. A portable unit could potentially reduce the cost of on-site odor measurements and improve the portfolio of available technologies field measurements. Compared with lab-based technology, the portable olfactometer overestimated the odor concentrations with the mean difference of 23 percent (ranging from 1 to 93 percent). The 2016 project was

funded by the Iowa Agriculture and Home Economics Experiment Station, State of Iowa and the Chungnam National University. Publication set for early 2018. *(Jacek Koziel, Agricultural & Biosystems Engineering; Heekwon Ahn, visiting faculty from Chungnam National University, Rep. of Korea)*

Evaluation of greenhouse gas emissions from land-applied swine manure.
Researchers [published (2017) results](#) of a two-season study on greenhouse gas emissions from a corn field treated with a typical fall/spring manure application. Emission rates for carbon dioxide, methane and nitrous oxide provide important missing data used by climate change models. One important finding was a lower than previously thought conversion rate of applied manure nitrogen into nitrous oxide. The study was funded by the National Pork Board (2010-2013). (*Jacek Koziel, Agricultural & Biosystems Engineering*)

Testing of deep pit manure additives. ISU and USDA-ARS researchers started a (2017-2018) one-year study co-funded by the National Pork Board and Indiana Pork to conduct pilot-scale testing of commercial pit additives marketed and used as deep pit manure additives for treatment and mitigation of key odor-causing gases, ammonia and hydrogen sulfide emissions. Products evaluated include those in most common use in commercial swine production in the U.S. and Indiana. This testing will provide side-by-side comparisons of additives to provide clarity to farmers about their impact on odor and manure properties, their cost and to provide scientific evidence to support or refute the claims of the manufacturer. In addition, pit manure additives also will be tested for their impact on manure properties including solids content and microbial community. The study also focuses on hydrogen sulfide mitigation during manure agitation, which is a key management issue for pig and human safety. *(Jacek Koziel, Dan Andersen, Agricultural & Biosystems Engineering; David Parker, USDA-ARS-Bushland)*

Extension manure applicator training (2000-Present). ISU organizes and delivers the annual [Iowa Manure Applicator Certification](#) program, a state-mandated training for confinement site and commercial manure applicators. The Iowa Department of Natural Resources funds the program through a contract with ISU Extension and Outreach. About 4,800 people were certified in the past year, with ISU faculty and extension specialists conducting workshops on regulatory requirements and odor control management practices. During the 2015 commercial applicators training, a module was presented on land application methods to conserve nutrients and minimize odor, and a follow-up session on how to adjust manure application equipment to achieve better incorporation and injection. *(Daniel Andersen, Agricultural & Biosystems Engineering)*

Evaluation of ammonia and odor emissions during land application of manure (2018). Moving manure nutrients from storage to field is an important part of sound nutrient management. This work is evaluating how different injection/incorporation equipment, soil and weather conditions and application rates interact to cause differences in ammonia and odor emission during application, and seeks to develop best management practices and recommendations for equipment set-up and use to minimize these odors. Funded by the Iowa Pork Producers Association. *(Daniel Andersen, Agricultural & Biosystems Engineering)*

Animal and manure management for sustainable production and reduced environmental impact (2014). Scientists found that low crude protein (CP) swine diets lowered manure pH and lowered odorous volatile organic compounds (VOC). Lower CP diets had reduced levels of both ammonia and VOCs being emitted from manure. Ammonia emissions were lowered by 9.4 percent for each 1 percent reduction in CP

content. Lower CP diets reduced odor by 5 percent for each 1 percent reduction in CP. The results have yet to be published. USDA-ARS funding. They have submitted a project in November 2017 to the National Pork Board titled, "Improved indoor air quality using low crude protein diets during periods of low ventilation." *(Brian Kerr, Steven Trabue, National Laboratory for Agriculture and the Environment, Daniel Andersen, Agricultural & Biosystems Engineering)*

Reducing the environmental footprint from agricultural systems through managing resources and nutrient inputs. The study starting spring 2018 will investigate the effects of crop residue levels, soil properties (i.e., moisture, texture, pH, etc.), manure properties (solids, pH, chemical concentrations, etc.) and mechanical application including tool bars for liquid injection, application rate and travel speeds through fields. The overall goal is to assess how to reduce emissions from field application of manure. USDA-ARS and Iowa Pork Producers funding. *(Steven Trabue, National Laboratory for Agriculture and the Environment, Daniel Andersen, Agricultural & Biosystems Engineering)*

Determining swine pit foaming causes and developing mitigation (2014-2016). Researchers investigated what effect diet grind size (i.e., particle size) had on emissions of odorants. They found that finer ground diets increased emissions of both ammonia and hydrogen sulfide by 20 percent and 40 percent, respectively. VOC emissions are still being summarized. USDA-ARS and Iowa Pork Producers funding. *(Brian Kerr, Steven Trabue, National Laboratory for Agriculture and the Environment, Daniel Andersen, Agricultural & Biosystems Engineering)*