Proposal #9

Title: Practical air scrubbers to reduce objectionable fan exhaust emissions from poultry production facilities in Texas.

Principal Investigator: Gerald Riskowski (Texas A&M University/Texas AgriLIFE Research)

Co-Principal Investigators: Saqib Mukhtar (Texas AgriLIFE Extension/Texas AgriLIFE Research), Craig Coufal (Texas AgriLIFE Extension/Texas A&M University) and David Parker (West Texas A&M University)

Amount Requested per year: $79,700 - FY2014; $61,100 - FY2015

Executive Summary:

There are increasing numbers of poultry production buildings, with large, densely housed flocks of birds, being constructed throughout the Texas countryside. These large production facilities emit large quantities of exhaust air that contain objectionable gases and particulates. The combination of many buildings being located near to neighbors and the large emissions of objectionable odors and particulates has led to many conflicts between producers and home owners. Cost effective solutions are needed to allow producers to meet the increasing demand for poultry products and, yet, reduce the environmental impact of the production facilities.

Unfortunately, there currently are no economical and practical methods of mitigating emissions from poultry buildings. A number of researchers have been studying biofilters but they have not provided a good solution primarily because of the high energy cost created by the high pressure drop required to move large quantities of ventilation air through the filters. Recent developments on wet spray air scrubbers have shown that it may now be possible to economically remove particulates, ammonia and other contaminants from large air streams. Researchers at the University of Illinois (UIUC), The Ohio State University (OSU) and Texas A&M University (TAMU) have developed small scale wet scrubbers that are very good at removing particulates and ammonia with relatively little increase in energy costs. We now need to take all that we have learned and develop an air scrubbing system that will be practical in an operating poultry facility.

Further challenges that need to be addressed are combining air scrubbers that have been optimized for particulates and for ammonia removal, optimizing air scrubbers for odor removal, and utilizing the nutrients that have been captured from the air cleaning process as a potential fertilizer. It is expected that a multi-stage air scrubber will be the most effective approach to removing all types of contaminants in the air. Exhaust air from poultry facilities has high quantities of particulates which will interfere with the gas scrubbing processes and likely need to be removed first. The second stage of the scrubber would be optimized for removing ammonia. We will test both regular water and acidic electrolyzed water (AEW) in the second stage and determine if odor levels are reduced in addition to ammonia.

In this proposal, we are requesting funding to apply the effective air scrubbing technology developed at TAMU to operate in the field at the TAMU poultry research facility. A multi-stage scrubber will be developed to effectively and economically remove particulates, ammonia and other odorous compounds from air emitted from poultry buildings. The scrubber design will also preserve nutrients removed from the air so they can be utilized for fertilizer. Findings from this research could also be applied to many other types of animal production facilities.

Proposal Narrative:

Goals and Objectives:

Poultry production facilities include egg production and meat production flocks. The increasing demand for quality poultry products has resulted in ever larger numbers of production buildings, with large, densely housed flocks of birds, being constructed throughout Texas. These large production facilities emit large quantities of exhaust air that contains objectionable gases and particulates. These emissions have led to many conflicts between producers and home owners. Cost effective and robust mitigation methods are needed before it will be practical to reduce the environmental impact of these production facilities.

Objectionable emissions: Large quantities of air need to be moved through poultry production buildings to provide fresh air for the birds and to cool the buildings in order to maintain a reasonable temperature for the birds. This ventilation air will collect large quantities of gases and particulates from within the buildings and exhaust them to the outdoor environment. The gases include significant amounts of ammonia and odorous volatile organic compounds. The particulates include significant concentrations of biological material such as feather fragments, feed, feces and micro-organisms. These gases and particulates can remain in noticeable concentrations for long distances from the exhaust point which has led to undesirable living conditions for neighboring residences, as well as potentially contaminating surface water.

A variety of methods have been tested for removing objectionable gases and particulates from exhaust air but most have failed primarily because of the high costs associated with cleaning large quantities of highly contaminated air. For example, biofilters have been shown to effectively remove particulates and odorous gases from air but the high pressure drops across biofilters require substantial additional energy costs to move the large quantities of air through the biofilter. Water and chemical spray scrubber technologies have shown some promise for this application because they can clean air with much lower pressure drops. Recent research conducted by some of the PIs has shown that water scrubbers can significantly reduce particulates and ammonia. Wet scrubbers spray water and other solutions directly into the air stream. The solution types and flow rates, and droplet sizes, need to be designed for the specific application – the optimum design for particulates can be very different than the optimum design for specific gases. It is difficult to scrub gases from air with regular water. Chemical air scrubbers can effectively remove specific gases from the air, but the costs of chemical scrubbers are significantly higher than water scrubbers. Chemical scrubbers often use highly acidic chemicals that lead to corrosion problems.

Fortunately, research funded by AgriLife Research and conducted by the PIs has developed an air scrubber that uses water and a small amount of sulfuric acid. This Texas A&M University (TAMU) scrubber removes up to 85% of the ammonia from the air and retains it as total ammoniacal nitrogen (TAN) in the scrubbing fluid. The scrubbing fluid can be recycled in this air cleaning process until the fluid reaches TAN and pH levels that are optimum for application to plants as fertilizer. Consequently, this greatly reduces the amount of water needed. These PIs used the TAMU scrubber to test both regular water (with controlled pH) and acidic electrolyzed water (AEW) as the scrubbing fluid. The AEW was around 4-10% more effective in removing ammonia from air than was regular water, when both were at a pH of around 7. AEW is a low cost fluid normally used for sterilization of surfaces and air and has been safely applied to numerous human occupied zones. It can be produced from water, salt and electricity at low cost. AEW reacts with ammonia, and possibly other odorous compounds, in the air to reduce them to more desirable compounds. However, it results in lower levels of total nitrogen in the scrubbing fluid than does the regular water with controlled pH (via a small amount of sulfuric acid).

AEW is generated by electrolysis of saline brine in a container with submerged anodic and cathodic electrodes. The resulting product contains high concentrations of free available chlorine (FAC) compounds - chlorine (Cl_2), hypochlorous acid (HOCl), and hypochlorite ion (OCl^-). When the pH of AEW is in the range of 5.5 to 7.5, it has the highest concentration of the desirable HOCl.

We are proposing to develop practical and robust air scrubbing technology and test it in the field at a facility housing broilers. A multi-stage scrubber will be developed to effectively and economically remove particulates, ammonia and odorous compounds from air emitted from poultry production buildings. We will test both regular water and acidic electrolyzed water (AEW) in the second stage and determine if odor levels are reduced in addition to ammonia. The scrubber design will also preserve nutrients removed from the air so they may be utilized for fertilizer. Findings from this research could also be applied to many other types of animal production facilities.

Methodology:

For this study, we are proposing to develop a multi-stage spray air scrubber to remove typical contaminants from the exhaust air of a facility housing broilers at 5-7 weeks of age. Stages of the scrubber will be optimized to remove the particulates, ammonia and odorous compounds. This study will be conducted at a poultry facility operated by the Poultry Science Department at TAMU which will provide typical poultry exhaust air. Four inches of aged litter will be placed on the floor prior to stocking birds in the room for each test. A flock of 200 broilers will be used for each test.

We will develop a larger scale (1000 cfm - 20 times larger than the lab scale scrubber tested in the previous study) spray air scrubber based on what we have learned in previous research. This scrubber will be designed in stages so we can attach different types of scrubbers in series in order to optimize removal of particulates, ammonia and odorous compounds from the exhaust air. The scrubber will be mounted on a frame just outside of the room exhaust so exhaust air can be passed through the scrubber. The scrubber fan will pull exhaust air from the room and pass it through the scrubber. The scrubber fan will be placed at the scrubber exhaust so as to not interfere with the contaminants in the air entering the scrubber. All instrumentation and sampling equipment will be housed in an environmentally controlled trailer adjacent to the scrubber.

Previous research has shown that particulates can be effectively removed by spraying regular water in a cross-flow pattern relative to the moving air stream. However, to remove gases, it is best to move air vertically and spray a specially selected fluid down into the upward moving air stream. The fluids will be carefully selected for the optimal removal of specific gases.

The field scrubber will have two to three stages. The first stage will be optimized for particulate removal and the second stage for ammonia removal. First, the particulate removal stage will be optimized and tested in the field. In addition to reducing particulate emissions, the first stage will greatly reduce problems that particulates may create in the more delicate process of removing gases in subsequent stages. Next, the second stage for ammonia removal will be combined with the first stage. Because the new ammonia scrubber will be 20 times larger than the previous lab scale scrubber, we will need to conduct lab tests on the new design to optimize the spray nozzle patterns. We will follow the same protocol as for the previous study.

For poultry facilities, ammonia is a major contributor to the perception of odor. The particulates also contribute to the odor emissions because odorous compounds adhere to them, plus some of the organic particulates emit odor. Consequently, removing large amounts of ammonia and particulates from the exhaust air emissions should significantly reduce the perception of odor levels. If the first two stages are found to be ineffective for odor reduction, then a third stage will be added for odor removal. There are other odorous compounds in the exhaust air that may be removable with spray scrubber technologies. Little research exists in the literature on removing odorous compounds with spray scrubbers, so additional research would need to be conducted in the laboratory to help optimize design parameters for removal of some of these other odorous compounds.

For each stage of the scrubber, the scrubbing fluid, nozzle type, contact time (between fluid and air), fluid-to-air quantity ratio, and fluid-to-air relative velocity will all be designed based on past research. The spray nozzles will have a solid cone pattern and move a relatively large amount of water through the air stream to optimize the collection of the gases. The air flow volume will be measured with a precision airflow nozzle. The length of the scrubber will have to be sufficient to give at least a 1 s contact time between the droplets and air with a relative fluid-to-gas velocity of around 2 m/s.

For each scrubber stage, scrubbing solution will be pumped from a reservoir to the nozzles in the scrubber and will flow back to the reservoir to be recirculated. Each stage will have its own solution and reservoir. For particulate removal, regular tap water will be used as the scrubbing solution. Solution contaminant levels will be monitored to determine how long the solution can be recycled before it needs to be replaced. Two types of solutions will be tested for the ammonia removal stage – regular tap water with pH continuously controlled at pH=2 and AEW with pH continuously controlled at pH – 5.5. One of the unique features of the recent scrubber research at TAMU is that continuously controlling pH of the scrubber solution greatly increases the efficiency of ammonia removal. The pH of the scrubbing solution will be regularly monitored and controlled to maintain a set value. Sulfuric acid will be used for dosing the scrubbing solution to maintain the pH at desired levels. TAN levels in the reservoir will be monitored and the water replaced when levels are appropriate for application as fertilizer.

Air will be sampled prior to entering the scrubber and right after the scrubber to determine the effectiveness of the scrubber in removing the contaminants of interest. Instrumentation for measuring the constituents in the sampled air will be located in an environmentally controlled clean trailer which will be parked on site. Air for particulate measurements will be sampled with isokinetic sampling inlets and there will be one air pump and filter system for each isokinetic sampler. Each sampler will draw air through a filter (47 mm diameter PTFE membrane filters). Airflow through each sampler will be continuously monitored with a sharp edged orifice and pressure transducer connected to a HOBO data logger. The filters will be conditioned in a laboratory at controlled temperature and relative humidity for a minimum of 24 h before weighing. Each filter will be weighed three times. If the standard deviation of the weights is less than 50 µg, the average of the three weights will be used. If the standard deviation is greater than 50 µg, the filters will be reweighed.

Ammonia levels will be sampled before and after the scrubber and analyzed with a chemiluminescence NH_3 analyzer. The NH_3 measuring equipment will consist of a Thermo Environmental Instruments 17C NH_3 convertor module and NH_3 analyzer. The ammonia analyzer system will be factory calibrated just prior to the overall experiment. The ammonia analyzer is reported to have a measurement range of 0.007 to 13.9 mg/m^3 (at atmospheric pressure- 1 atm, and ambient temperature – 25^{o}C) and an accuracy of 0.5% of the ammonia reading. The calibration of the ammonia system will be checked periodically against standard gases.

Odor samples will be collected in 10 L Tedlar bags at locations before and after the scrubber. To reduce ambient bag odor, each bag will be heated for 24 h at 100°C and purged with odor-free air before the odor samples are collected. Samples will be shipped by overnight delivery to the odor laboratory at West Texas A&M University and analyzed following standardized procedures (ISU/UM, 2000). Odor samples will be presented to trained panelists and analyzed for odor concentration (OC), intensity, and hedonic tone. All sampling and analyses for human subjects will follow guidelines approved by the WTAMU Institutional Review Board (IRB).

Once an optimized multi-stage spray scrubber has been developed, it will be continuously operated and monitored for 2-week periods in the months of October, February and July. We will measure particulate and ammonia reductions three times, and odor reduction once each week of operation. Regression analysis will be conducted to determine the effect the scrubber on the contaminant removal efficiency for each test period of the year.

It is expected that six flocks of 200 broilers each will need to be raised over the 2 year study. The first three flocks will be needed for development and the last three flocks will be needed for testing.

Deliverables:

This research will provide a practical, economical design for a system to scrub significant levels of particulates, ammonia and odor from exhaust air of poultry production facilities in Texas. The design parameters provided by the results of this study should be readily scaled up for the design of a commercial scrubber. The first year of the study will involve optimizing and field testing of each of the stages for the multi-stage spray scrubber. During the second year, the scrubber will be operated for long periods of time for three seasons of the year, to identify and mitigate practical operating problems.

Activity	**Months**	
Project Begins: October 1, 2013	**1-12**	**13-24**
Develop and optimize large-scale multi-stage spray scrubber	X	
Raise three poultry flocks per year	X	X
Year 1- Optimize and field test each scrubber stage	X	
Year 2- Field test long-term operation and mitigation potential of scrubber		X
Observation and Sampling	X	X
Data Analysis of Results		X
Publications and other educational materials development		X
Presentations of preliminary and final results	X	X
Progress Report	X	
Final Report		X
Project Ends: September 30, 2015		

Individual Responsibilities:

Dr. Gerald Riskowski will serve as the overall coordinator of this research. He has conducted research on gaseous emissions from animal buildings and on wet scrubbers for removing particulates and gases from ventilation exhaust air. Dr. Saqib Mukhtar has conducted research on emissions from poultry facility including some current studies on mitigation methods for removing emissions from poultry facilities, and will be responsible providing practical solutions to the scrubber design. Dr. Craig Coufal, has conducted research on poultry emissions and will be responsible for field operations and flock management. Dr. David Parker will be responsible for conducting odor analyses of air samples.

Potential for Leveraging Resources:

Our mitigation method for removing particulates, ammonia and other contaminants from air emitted from poultry buildings described in this proposal is novel and is not yet presented in the literature. Consequently, the chance of being successful in receiving a grant from federal or other sources is low until we can provide basic data to prove the technology. This grant would allow us to obtain the data needed to pursue higher levels of funding for further research on these novel technologies.

Most studies on contaminants from animal buildings have been on determining emission levels and fewer have been done on mitigation of the problem. Of the research that has been done on removing contaminants from animal building emissions, none have been proven to be practical and economical in removing the particulate and gaseous contaminants from the large volumes of ventilation air that is emitted from these building. Spray scrubbers have the potential to clean large volumes of air without substantially increasing initial costs and energy costs. However, much more research is needed to optimize their effectiveness in removing particulates and gases that will use a low cost scrubbing fluid that will also retain valuable nutrients captured from the air. We also need to demonstrate the potential of reducing odor levels of the emissions by using a well-designed wet air scrubber and the appropriate scrubber fluid. Based on research conducted by the PIs during recent years, it is feasible to create an effective spray scrubber that does not have the challenges of other scrubber designs that utilize chemicals with high acidity. However, research is needed to provide data to demonstrate the effectiveness of these systems in field applications. We will also need to study methods of practical handling the nutrient rich scrubbing fluid after it is utilized in the wet scrubber. Findings from this research could also be applied to many other types of animal production facilities.

Because other methods for mitigating contaminants from the exhaust air of animal buildings are currently limited or impractical, we should be very competitive in seeking additional funding from federal and state sources, if we can provide data to show high potential for using this technology. This grant would also allow us to establish a field research facility that would make us more competitive in future proposals. Results of the previously funded AQI research on laboratory wet scrubbers resulted in two papers being submitted for peer-reviewed journals, and a conference paper. Based on the results of the wet scrubber research, Riskowski/Mukhtar submitted a proposal to USDA AFRI in 2013 that emphasized capturing ammonia for utilization as a fertilizer, which is currently under review. Riskowski/Mukhtar also submitted a proposal to an USDA NIFA RFP in 2012 that emphasized mitigation of greenhouse gases which was unfunded. We will continue to pursue funding from Federal and State sources such as the USDA-AFRI, EPA and the Conservation Innovation Grant programs.

Budget:

The first year will require the most resources in order to construct the field wet scrubber system and remodel the trailer. We are requesting a graduate student stipend and two undergraduate student workers for both years. We will be able to utilize existing equipment and supplies to reduce costs, but instrumentation needs to be factory calibrated before it can be used. Funds are also needed for raising the flocks and for odor analyses.

<u>FY2014:</u>

Graduate student stipend – $23,000
Undergraduate research assistants - $15,000
Wet scrubber apparatus - $20,000
Calibrated gas supplies - $4,000
Gas/particulates measuring system calibrations and supplies - $8,000
Upgrade trailer for housing scientific equipment at a field study site - $3,000
Poultry flock bird fees - $2,500
Odor analyses of air samples - $4,200

Total for FY2014 = $79,700

<u>FY2015:</u>

Graduate student stipend - $24,000
Undergraduate research assistants - $15,000
Gas/particulates measuring and general supplies - $7,000
Poultry flock bird fees - $2,500
Odor analyses of air samples - $12,600

Total for FY2015 = $61,100

Portions of budget allocated to each PI/Co-PI:

Riskowski/Mukhtar - $55,500 for FY2014; $34,000 for FY2015.
Mukhtar - $11,000 for FY2014; $5,500 for FY2015.
Coufal - $9,000 for FY2014; $9,000 for FY2015.
Parker - $4,200 for FY2014; $12,600 for FY2015.

ATTACHMENTS FOLLOW:

Interim Report for AQI funded project by PI in FY2012-2013.

CVs of PI and Co-PIs.

Two Page Interim Report from previous AQI funding – 9/1/2011 to Present:

Title: Using acidic electrolyzed water to reduce objectionable gas emissions from poultry production facilities in Texas.

Principal Investigator: Gerald Riskowski (Texas A&M University/Texas AgriLIFE Research)
Co-Principal Investigators: Saqib Mukhtar (Texas AgriLIFE Extension/Texas AgriLIFE Research)
Collaborators: Lingying Zhao (The Ohio State University); Wei Fang (National Taiwan University)

All objectives of the study were achieved and an effective ammonia scrubber was developed. Three basic types of lab scale scrubbers were tested. All were laboratory scale and operated under laboratory conditions in order to better assess the impact of the different individual design parameters.

1. Packed bed scrubber for scrubbing ammonia from air.
2. Spray scrubber for removing ammonia from air.
3. Energized ozone scrubber for removing methane from air.

Packed Bed Scrubber Experiments:

The packed bed scrubber was very efficient at removing ammonia from air. With a contact time of 1 s, the ammonia removal efficiencies varied from 52% to 74%. With a contact time of 17 s, the efficiencies ranged from 80% to 100%. For the 1 s contact time, the electrolyzed water at 50 ppm total chlorine content had better removal efficiencies than regular water. Electrolyzed water with total chlorine content of 19 ppm or 148 ppm had about the same removal efficiency as regular water. Electrolyzed water at high total chlorine contents (270 ppm) had removal efficiency lower than regular water. Electrolyzed water showed an optimum total chlorine content of around 50 ppm for the process of scrubbing ammonia from air in a packed bed scrubber. However, packed bed scrubbers create high pressure drops that require special fans that use large amounts of energy to overcome the pressure drop.

Spray Scrubber Experiments:

Spray scrubbers normally create little pressure drop so they do not significantly increase energy consumption or require special fans. However, previous research has indicated that they are not very efficient for scrubbing ammonia from the air – around 10-30% removal efficiency with regular water. In an effort to improve the efficiency, we conducted experiments to test the effect of various design parameters.

We constructed a laboratory scale spray scrubber and designed it so airflow rate, water flow rate, nozzle type, contact time, and scrubbing fluid could be readily changed. For the first experiment, the spray scrubber was tested with two different spray nozzles, three different contact times, and three different spray fluids. The two nozzles had narrow and wide patterns. The contact time was the time that the spray contacted the air to be scrubbed and the values tested were 0.3, 0.6, and 0.9 s. The fluids tested were filtered water, electrolyzed water with pH = 9.0, and electrolyzed water with pH = 6.5. Total chlorine content of the electrolyzed water was set at 50 ppm. In general, the narrow nozzle, longer contact time and electrolyzed water with pH = 6.5 provided the best scrubbing results. For the narrow nozzle, regular water removed 35% of the ammonia at 0.3 s and 50% at 0.9 s contact time. The electrolyzed water (with pH = 6.5) removed 38% (0.3 s) to 56% (0.9 s) of the ammonia. The first experiment showed that the electrolyzed water was 1.3-16.5% more efficient than the regular water. We also noticed that the pH of the scrubbing fluid increased over the test period which resulted in a decrease of removal efficiency. (The scrubbing fluid was recycled and the first experiment operated for around 30 minutes). As a result, we decided to run a second experiment with regular water where we maintained constant pH at different levels, and to operate the spray scrubber for a few hours. A paper has been developed on the first experiment and will be submitted to a peer-reviewed journal soon, and we presented this information at a conference (Riskowski et al., 2013).

In the second set of experiments with the spray scrubber, we tested the ammonia removal efficiencies of using (1) regular water without maintaining the pH and (2) regular water with the pH continuously controlled at 5 different levels (2, 3, 4, 6 and 8). The pH of the scrubbing fluid was continuously measured and small quantities of sulfuric acid were added as needed to maintain the pH at the desired level. For the second experiment, only the narrow nozzle and regular water were used. However, the air velocity through the scrubber was tested at three different levels – 1.3, 2, and 3 m/s which provided contact times of 0.95, 0.62, and 0.41 s, respectively. For the test where pH was not controlled, the pH of the water started at 7.8 and quickly rose to 9.7 and the ammonia scrubbing efficiency started at 50% and dropped to 13% at the end of the 210 min run. For the tests where pH was maintained at a constant level, the ammonia removal efficiency remained constant throughout each 210 min long run and averaged: pH=2 – 84.3%, pH=3 – 73.9%, pH=4 – 63.8%, pH=6 – 56.7%, pH=8 – 49%. In all cases, the total ammoniacal nitrogen (TAN) in the recycled scrubbing fluid started out at 0 ppm but continued to increase throughout the 210 minute run.

Based on the results of the wet scrubber, we submitted a proposal to USDA AFRI which emphasized capturing ammonia for utilization as a fertilizer. Capturing ammonia from air with wet scrubbers was a major portion of that proposal. The proposal will be reviewed this summer. We are also completing a peer-reviewed paper on the second set of experiments.

Energized Ozone Scrubber for Methane Removal:

Scrubbing methane from air is a major challenge, because methane is very stable in air at low concentrations and low ambient temperatures. We tried a wide variety of ideas to find something that may work under these conditions and found a combination of treatments that consistently removed some methane from the air. We discovered that by adding ozone to the methane/air and then energizing this mixture with UV light, we were able to reduce the methane concentrations. In this experiment, we made a mixture of air which had 33 ppm of CH_4 and 1.35 ppm of O_3, then subjected the mixture to UV light (254 nm wavelength) which resulted in removing 7% of the methane. Although this is not a high reduction, it is the first time that anyone has been able to remove methane under these conditions.

Based on these results, we submitted a proposal to an USDA NIFA RFP that emphasized mitigation of greenhouse gases. Unfortunately, the 7% methane removal was not high enough to generate sufficient interest in funding a study to increase this efficiency.

Riskowski, G., A. M. Samani Majd., A. Kalbasi and S. Mukhtar. 2013. Ammonia (NH3) Mitigation Using Electrolyzed Water Spray Scrubber. In proceedings of the 2013 National Conference, From Waste to Worth: Spreading Science and Solutions. April 1-5, 2013. Denver, CO. Available at: http://www.extension.org/67656

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Educational Background

B.S.	Agricultural Engineering, University of Nebraska	1974
M.S.	Agricultural Engineering, University of Nebraska	1976
Ph.D.	Agricultural Engineering, Iowa State University	1986

Professional Employment

Professor, Biological & Agricultural Engineering, Texas A&M Univ., 9/1/2010 to present
Department Head, Biological & Agricultural Engineering, Texas A&M Univ., 1/1/02 to 8/31/2010
Assist., Assoc, Full Professor in Agricultural Engineering, Univ. of Illinois, Urbana, IL, 1986-2001
Instructor and Extension Engineer, Iowa State University, Ames, IA, 1980-1986
Design Engineer, Lester's & Wick Building Systems, MN & WI, 1976-1980

Honors, Recognitions and Outstanding Achievements

- Fellow ASABE, 2007
- ASA(B)E Henry Giese Award, 2001
- Rural Builders Hall of Fame, 1998
- ASA(B)E Outstanding Paper Award, 1994.
- ASA(B)E Superior Paper Awards, 2000 and 2001.
- ASABE Honorable Mention Paper Award, 2006.
- ASHRAE Technical/Symposium Paper Awards, two in 2001, one in 2002
- Eight ASA(B)E Blue Ribbon Awards for publications.
- Invited lectures in Brazil, China, Europe, Korea, Taiwan and USA
- Teaching Academy, College of ACES, University of Illinois, Urbana-Champaign, 1993-1996
- Gamma Sigma Delta, Illinois Chapter, Secretary, Vice President, President

Accomplishments

Dr. Riskowski is currently Professor and has served as Head of Department for 9 years at the Biological & Agricultural Engineering, Texas A&M University. Prior to that, he was Professor and Leader of the Bioenvironmental Engineering division of the Agricultural Engineering Department, University of Illinois at Urbana-Champaign. He is recognized internationally for his research concerning environmental control systems, emission mitigation from animal facilities, and light-frame structures. He was a principal investigator on several projects sponsored by NIH, NASA, NSF, ASHRAE and industry. He was a founder and director of the Bioenvironmental and Structural Systems (BESS) Laboratory at UIUC. His publication record includes 82 peer-reviewed journal articles and over 100 conference papers. He has authored 9 handbooks, an ASA(B)E standard, 10 monographs and book chapters, and has given several invited lectures around the world. He has been an associate editor for ASABE journals since 1994. His papers have received four ASA(B)E paper awards and three ASHRAE Technical Paper awards. Other honors have included 8 Blue Ribbon awards, an Outstanding Reviewer award from ASA(B)E, and teaching excellence awards. He was also elected into the rural Builders Hall of Fame, received the ASA(B)E Henry Giese Award, and is a Fellow of ASABE.

Current Research:

Dr. Riskowski is currently conducting research in the area of bioenvironmental engineering. His program has a wide variety of research dealing with environmental issues resulting from production of animals and plants. Some of the current research projects include mitigating air quality problems due to emissions from livestock facilities, new technologies in utilizing nutrients from waste streams, effects of environment on expression of desirable chemicals in plants, and tracking of micro-organisms in ventilated spaces.

Publications:

Ford, S.E. and G.L. Riskowski. 2003. Effect of windbreak wall location on ventilation fan performance. Applied Engineering in Agriculture 19(3):343-346.

Medjio, R. and G.L. Riskowski. 2003. Potential of stabilized backfill soils for post-frame foundations. African Journal of Materials and Minerals 6(1): 5-12.

Miller, G.Y., R.G. Maghirang, G.L. Riskowski, A.J. Heber, M.J. Robert, and M.E.T. Muyot. 2004. Influences on air quality and odor from mechanically ventilated swine finishing buildings in Illinois. Journal of Food, Agriculture and Environment 2(2): 353-360.

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Wang, X., Y. Zhang, T.L. Funk, L. Zhao and G.L. Riskowski. 2004. Effect of ventilation system on particle spatial distribution in ventilated rooms. ASHRAE Transactions. 110 (2): 258-266.

Elenbaas-Thomas, A.M., L.Y. Zhao, Y. Hyun, X. Wang, B. Anderson, G.L. Riskowski, M. Ellis and A.J. Heber. 2005. Effects of room ozonation on air quality and pig performance. Transactions of the ASAE 48(3):1167-1173.

Riskowski, G.L., P.C. Harrison, F. Memarzadeh. 2006. Mass generation rates of ammonia, moisture, and heat production in mouse cages with two bedding types, two mouse strains, and two room relative humidities. ASHRAE Transactions 112(1):134-144.

Zhao, L.Y., Y. Zhang, X. Wang, and G.L. Riskowski. 2007. Analysis of airflow in a full-scale room with non-isothermal jet ventilation using PTV techniques. ASHRAE Transactions 113(1):414-425.

Chang, A.C., T. Y. Yang, and G.L. Riskowski. 2013. Changes in nitrate and nitrite concentrations over 24 h for sweet basil and scallions. Food Chemistry 136(2013)955-960.

Chang, A.C., T.Y. Yang and G.L. Riskowski. 2013. Ascorbic acid, nitrate, and nitrite concentration relationship to the 24 hour light/dark cycle for spinach grown in different conditions. Food Chemistry 138(2013)382-388.

Faulkner, W.B., F. Memarzadeh, G.L. Riskowski, K. Hamilton, A.C. Chang, and J.R. Chang. 2013. Particulate concentrations within a reduced-scale room operated at various air exchange rates. Building and Environment (accepted) BAE_3390.

Saqib Mukhtar, P.E. 201-A Scoates Hall, 2117 TAMU College Station, TX 77843-2117 mukhtar@tamu.edu	Professor and Assoc. Dept. Head Biological & Agricultural Engineering Texas AgriLife Extension and Research Texas A&M System

EDUCATION

- Ph.D. in Agricultural Engineering with Minor in Water Resources. Iowa State University. May, 1989.
- M.S. in Agricultural Engineering. Iowa State University. May, 1984.
- B.S. in Agricultural Engineering. University of Agriculture, Faisalabad, Pakistan. August 1981.

Employment History

Associate Department Head. (February 2012-Present)
Interim Associate Department Head. *(November 2010-Present)*
Professor and Extension Ag. Engineer. *(September 2004-Present)*
Assistant Professor and Extension Ag. Engineer. *(August 1998- August 2004)*
Department of Biological and Agricultural Engineering, Texas A&M University, College Station, Texas.
Faculty, Water Management and Hydrologic Science Interdisciplinary Graduate Degree program (2008-present)
Faculty, Center for Agricultural Air Quality Engineering and Science (CAAQES). Texas A&M University, College Station, Texas (2002-present).

Related Work Experience

Subject matter expertise and responsibilities are to provide leadership, delivery and support for research and Extension programs in engineering systems related to environmental quality management of animal feeding operations in Texas. Guide graduate student research, and provide engineering leadership to interdisciplinary and interagency programs involving improved manure and wastewater practices for air and water quality protection, animal mortality management, waste utilization and design of environmentally sustainable facilities. Administrative responsibilities include program leadership and supervision of Extension faculty and staff of the Biological and Agricultural Engineering Department Extension and outreach education programs.

Agricultural Engineering Field Specialist. Iowa State University Extension, Osceola, Iowa. (June 1993- July 1998).
Provided program leadership, delivery and support for manure and wastewater management aspects of livestock and poultry production, processing systems, and environmental quality in a 14 county central Iowa area.

Civil Engineer. (September 1990 to June 1993)
USDA-Natural Resources Conservation Service, Iowa.
Provided engineering assistance to field office staff, district cooperators and other land users for planning, design and construction of animal waste management, soil erosion and flood control structures.

Postdoctoral Research Associate. (April 1989 to August 1990)
Department of Agricultural & Biosystems Engineering, Iowa State University, Ames, Iowa

Graduate Research Assistant. (September 1982 to April 1989)
Department of Agricultural & Biosystems Engineering, Iowa State University, Ames, Iowa.

Recent Grants and Contracts (Last five years)

1. Co-PI (PI, Richard Stowell, University of Nebraska) on National Facilitation of Extension Programming in Climate Change Mitigation and Adaptation for Animal Agriculture. USDA-National Institute of Food and Agriculture (NIFA). $4,290,000. 2011-2016.
2. PI on Evaluation of Electrostatic Particle Ionization and Biocurtain© Technologies to Reduce Dust, Odor and other Pollutants from Broiler Houses. Texas State Soil and Water Conservation Board (TSSWCB). $169,624. 2010-2012.
3. Co-PI on Research, Education and Extension Program for Sustainable Manure Management Practices-Learning from the Belgian Model. USDA/CSREES International Science and Education (ISE) grant. $149,999. 2009-2013.
4. Co-PI on Preparing Underrepresented Scholars For Challenges in Agricultural Biosecurity and Sustainability – A Research and Leadership PhD Program. USDA-CSREES grant. $229,500. 2008-2012.
5. PI on Assembly and Testing of an On-Farm Manure to Energy Conversion System BMP For Animal Waste Pollution Control. USDA-NRCS, CIG grant. $68,570. 2007- 2008.

Graduate Student Committees

Major Professor or Co-Chair of 6 M.S., 5 Ph. D. Students, and Committee Member of 2 Ph.D. and 12 M.S. Students since 1999.

Graduated 5 M.S. and 4 Ph.D. Students since 2002.

Recent Awards and Honors

1. The Association of Former Students (TAMU) University –Level Distinguished Achievement Award in Extension and Education. 2013.
2. National Excellence in Multistate Research Award, Experiment Station Committee on Organization and Policy (ESCOP), June 2011. (USDA-NIFA Multistate Research Committee S-1032)
3. The 2010 American Society of Agricultural and Biological Engineering (ASABE) Gunlogson Countryside Engineering Award. June, 2010.
4. The 2010 Texas Commission on Environmental Quality (TCEQ) Texas Environmental Excellence Award in Agriculture. Team included members from Texas AgriLife Research, Texas AgriLife Extension Service, West Texas A&M University, Kansas State University, and USDA-Agricultural Research Service, Amarillo, TX. May 2010.
5. Excellence in Extension Education Award. Biological and Agricultural Engineering Department, Texas A&M University. April, 2010.
6. Texas A&M AgriLife Vice Chancellor's Award in Excellence, January 2009. In recognition of outstanding contribution and performance as a member of "Air Quality: Reducing Feedlot Emissions Research Team."
7. Texas A&M AgriLife Extension Service--Superior Service Award, January 2008. Commendation for developing effective waste management education programs that successfully improve the profitability of dairy and poultry producers and their ability to fully comply with environmental regulations.

Recent publications (Last five years)

1. Borhan*, M. S., S. C. Capareda, **S. Mukhtar**, W. B. Faulkner, R. McGee and C. B. Parnell, Jr. 2012. Comparison of seasonal phenol and p-cresol emissions from ground-level area sources in a dairy operation in central Texas. Journal of the Air & Waste Management Association. 62: 381-392.
2. Gallagher*, M. A., R. Karthikeyan and **S. Mukhtar**. 2012. Growth kinetics of wildlife E. coli isolates in soil and water. 2012, 3, 838-846
3. Padia*, R., R. Karthikeyan, **S. Mukhtar** and I. Parker. 2012. Occurrence and fate of E. coli from various non-point sources in a subtropical watershed. Journal of Natural & Environmental Sciences. 2012 3(1): 9-18.
4. **Mukhtar, S.,** S. Borhan* and J. Beseda II. 2011. Evaluation of a Weeping Wall Solid-Liquid Separation System for Flushed Dairy Manure. Applied Engineering in Agriculture. 27(1): 135-142.
5. Borhan*, M. S., S. C. Capareda, **S. Mukhtar**, W. B. Faulkner, R. McGee and C. B. Parnell, Jr. 2011. Greenhouse Gas Emissions from Ground Level Area Sources in Dairy and Cattle Feedyard Operations. *Atmosphere* (2) 303-329.
6. Borhan*, M. S., S. C. Capareda, **S. Mukhtar**, W. B. Faulkner, R. McGee and C. B. Parnell, Jr. 2011. Determining Seasonal Greenhouse Gas Emissions from Ground-Level Area Sources in a Dairy Operation in Central Texas. Journal of the Air & Waste Management Association. 61: 786-795.
7. Giri, S*. **S. Mukhtar** and R. Wittie. 2010. Vegetative Covers for Sediment Control and Phosphorus Sequestration from Dairy Waste Application Fields. Transactions of the ASABE. 52 (3) 803-811.
8. Capareda, S. C., **S. Mukhtar**, C. Engler and L. B. Goodrich*. 2010. Energy usage survey of dairies in the Southwestern United States. Applied Engineering in Agriculture. 26 (4): 667-675.
9. **Mukhtar, S.,** S. Borhan*, S. Rahman and J. Zhu. 2010. Evaluation of a field-scale surface aeration system in an anaerobic poultry lagoon. Applied Engineering in Agriculture. 26(2): 307-318.
10. **Mukhtar, S**., A. Mutlu*, R. E. Lacey and C. B. Parnell. 2009. Seasonal ammonia emissions from a free-stall dairy in central Texas. Journal of the Air & Waste Management Association. 59: 613-618.
11. **Mukhtar, S.,** M. L. McFarland and C. A. Wagner. 2008. Runoff and water quality from inorganic fertilizer and erosion control compost treatments on roadway sideslopes. Transactions of the ASABE. 51(3): 927-936.
12. **Mukhtar, S**., S. S. Sadaka*, A. L. Kenimer, S. Rahman* and J. G. Mathis*. 2008. Acidic and alkaline bottom ash and composted manure blends as a soil amendment. Bioresource Technology. 99 (2008) 5891-5900.
13. **Mukhtar, S**., A. Mutlu*, S. Capareda, and C. B. Parnell. 2008. Seasonal and spatial variations of ammonia emissions from an open-lot dairy operation. Journal of the Air & Waste Management Association. 58: 369-376.
14. Rahman, S.* and **S. Mukhtar**. 2008. Efficacy of microbial treatment to reduce phosphorus and other substances from dairy lagoon effluent. Applied Engineering in Agriculture. 24 (6): 809-819.

*****Graduate student or research associate.

CURRICULUM VITAE

CRAIG D. COUFAL
Assistant Professor and Extension Specialist
Department of Poultry Science, Texas A&M University
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EDUCATION

Ph.D., Poultry Science, Texas A&M University, 2005
M.S., Poultry Science, Texas A&M University, 2000
B.S., Poultry Science, Texas A&M University, 1997

PROFESSIONAL EXPERIENCE

August, 2008 - present	**Assistant Professor and Extension Specialist**, Department of Poultry Science, Texas A&M University, College Station, Texas
2006 - 2008	**Assistant Extension Professor**, Department of Poultry Science, Mississippi State University, Mississippi State, Mississippi
2005 - 2006	**Post-doctoral Research Associate**, Department of Poultry Science, Texas A&M University, College Station, Texas
2004 - 2005	**Graduate Assistant**, Department of Poultry Science, Texas A&M University, College Station, Texas
2001 - 2003	**Extension Associate**, Department of Poultry Science, Texas A&M University, College Station, Texas
1998 - 2000	**Graduate Assistant**, Department of Poultry Science, Texas A&M University, College Station, Texas
1997 - 1998	**Production Supervisor**, Cal-Maine Foods, Inc., Waelder, Texas

ACADEMIC HONORS AND AWARDS

2006 Alltech Student Research Manuscript Award, Poultry Science Association
2011 Early Achievement Award for Extension, Poultry Science Association
2013 Faculty Award of Merit for Extension, Gamma Sigma Delta, Texas A&M University Chapter

CURRENT EXTENSION WORK

- Provide technical assistance, training and education programs to poultry companies, poultry producers and the general public.
- Respond to daily extension clientele phone calls and emails.
- Lead specialist for poultry youth programs.
- Extension programs: Market Poultry Production and Selection Workshop, Small-scale Poultry Production Workshop, Egg Grader Training for Small Flock Producers, Nuisance Odor Prevention Training for Poultry Producers

CURRENT TEACHING RESPONSIBILITIES

POSC 427 Animal Waste Management, 2008 -present
POSC 326 Commercial Egg Industry, 2009 – present

GRADUATE STUDENT ADVISING

Committee chair for 6 M.S. students, committee member for 5 M.S. students, and committee chair for 1 M.Ag. student and committee member for 1 M.Ag. student.

GRANTS AND CONTRACTS AWARDED

Sanitation of hatching eggs by high-intensity ultraviolet light irradiation. Mississippi State University, funded by US Poultry and Egg Association Project #F022: $19,297 (co-investigator). October 1, 2007 – October 1, 2009.

Environmental effects of in-house windrow composting of poultry litter. Texas A&M University, funded by Texas State Soil and Water Conservation Board CWA §319(h) NPS Grant Program: $447,080 (co-investigator). September, 2009 – August, 2013.

Study of BioWish as a litter amendment and feed ingredient to reduce fecal odor in market broilers. Texas A&M University, funded by Biowish Technologies, Inc,: $48,238.06 (co-investigator). 2010 – 2012.

Development of best practices for shell egg disinfection based upon efficacy, egg quality, and economics. Texas A&M University, funded by US Poultry and Egg Association Project #F041: $15,295 (co-investigator). October 1, 2011 – October 1, 2013.

Evaluation of a process and equipment for rapid eggshell disinfection under commercial conditions. Texas A&M Univesity, funded by Cobb-Vantress, Inc., Project no. 07-442190. $45,945. October 1, 2012 – December 31, 2013.

PROFESSIONAL ORGANIZATION AND COMMITTEE SERVICE

Poultry Science Association

- Associate Editor for *Poultry Science*, 2010 - present
- Ad hoc reviewer for *Journal of Applied Poultry Research*
- Chair, Extension Symposium, 2009 annual meeting
- Extension/Outreach Committee and Phibro Extension Award, member, 2007 – 2009
- Section chair for Environment and Management section, 2008 annual meeting

Southern Poultry Science Society

- Session chair, Environment and Management, International Poultry Science Forum, Atlanta, GA, 2007 and 2012

S1035: Nutritional and Management Abatement Strategies for Improvement of Poultry Air and Water Quality (from W195) multi-state research project, member, 2006 – present

National Poultry Waste Management Symposium, 2008 and 2010 planning committee member, co-chair for 2012 symposium, chair for 2014 symposium

Total Abstracts: 43
Peer-reviewed journal publications: 17
Extension publications: 4
Conference proceedings: 13
Invited speaker: 7

David B. Parker, Ph.D., P.E.
Professor and Director, Commercial Core Laboratory
Palo Duro Research Center
West Texas A&M University
Canyon, Texas 79016

Career Summary: *Dr. Parker is a registered Professional Engineer with 26 years of experience working for engineering consulting firms, private industry, federal government, and academia. His experience includes nine years as a civil and environmental engineer in private consulting, and 14 years as Assistant, Associate, and Full Professor in the Department of Agricultural Sciences at West Texas A&M University (WTAMU). From 2010-2012, he served as Research Leader of the Environmental Management Research Unit at the USDA-ARS Meat Animal Research Center in Clay Center, Nebraska. As administrative leader of the unit, he supervised five Ph.D. scientists/engineers and five research technicians, and was responsible for all research planning and budgetary oversight. Since May, 2012 he has been the Director of the new Commercial Core Laboratory located on the West Texas A&M University campus. The Core Lab provides air quality and odor analyses for on-campus and off-campus clients, and assists private companies with custom research services and product development.*

Education and Training

New Mexico State University	Agric. Engineering	B.S. 1985
University of Wyoming	Agric. Engineering	M.S. 1987
University of Nebraska	Biological Systems Engineering	Ph.D. 1996

Employment History

2012-present	Director, Commercial Core Laboratory, West Texas A&M University
2010-2012	Research Leader, USDA-ARS, Clay Center, NE
2006-2010	Professor of Agriculture, West Texas A&M University, Canyon, TX
2002-2006	Associate Professor, West Texas A&M University, Canyon, TX.
1997-2002	Assistant Professor, West Texas A&M University, Canyon, TX.
1987-1996	Consulting Environmental Engineer, Morrison-Knudsen Engineers (Idaho), Weyerhaeuser Paper Company (Washington), Power Engineers (Idaho and Nebraska)

Professional Registration

Registered Professional Engineer: Washington and Texas

Professional Activities

American Society of Agricultural Engineers - Member since 1987
ASAE Committee SE-412, Waste Management, President 2002-2003
ASAE Committee SE-04, Paper Awards, 2003-2005
Associate Editor, Applied Engineering in Agriculture 2002-2004

Honors and Awards

2011 – USDA-ARS Certificate of Merit for Superior Performance Appraisal 2010-2011.
2010 – Notable Technology Development Award, presented by the Federal Laboratory Consortium for Technology Transfer - "Database of Emission Levels in Cattle Feedyards for EPA Compliance."
2010 - Texas Environmental Excellence Award in Agriculture - "Air Quality: Reducing Emissions from Cattle Feedlots and Dairies." Presented by the Governor and Senate of the State of Texas.
2008 – Texas A&M University, Chancellor's Research Recognition Award

Relevant Publications (Lifetime Publications >200, Peer-reviewed (60), Conf. Proceedings (129), Abstracts (19), Extension Pub. (2), Book Chapters (3)

Parker, D.B., J. Gilley, B. Woodbury, K-H Kim, S. Bartelt-Hunt, X. Li, D. Snow, G. Galvin. 2013. Odorous VOC emission following land application of swine manure slurry. Atmos. Env. 66:91-100.

Parker, D., J. Ham, B. Woodbury, L. Cai, M. Spiehs, M. Rhoades, S. Trabue, K. Casey, R. Todd, N. Cole. 2013. Standardization of flux chamber and wind tunnel flux measurements for quantifying volatile organic compound and ammonia emissions from area sources at animal feeding operations. Atmos. Env. 66:72-83.

Spiehs, M. J., T. M. Brown-Brandl, D. B. Parker, D. N. Miller, E. D. Berry, J. E. Wells. 2013. Effect of bedding materials on concentration of odorous compounds and Escherichia coli in beef cattle bedded manure packs. Journal of Environmental Quality 42(1):65-75.

Bereznicki, S.D., A.J. Heber, N. Akdeniz, L.D. Jacobson, B.P. Hetchler, K.Y. Heathcote, S.J. Hoff, J.A. Koziel, L.S. Cai, S. Zhang, D.B. Parker, E.A. Caraway, T.T. Lim, E.L. Cortus, and R.B. Jacko. 2012. Odor and odorous chemical emissions from animal buildings: Part 1 – Project overview, collection methods, and quality control. Trans. ASABE 55(6):2325-2334.

Parker, D.B., L. Cai, J. A. Koziel, L. Jacobson, N. Akdeniz, S. Bereznicki, T. Lim, E. Caraway, S. Zhang, S. J. Hoff, A. J. Heber, K. Heathcote, B. Hetchler. 2012. Odor and odorous chemical emissions from animal buildings: Part 6 – Odor activity value. Trans. ASABE 55(6):2357-2368.

Parker, D. B., L. Cai, K-H Kim, K. E. Hales, M. J. Spiehs, B. L. Woodbury, A. L. Atkin, K. W. Nickerson, K. D. Patefield. 2012. Reducing odorous VOC emissions from swine manure using soybean peroxidase and peroxides. Bioresource Technology 124:95-104.

Hales, K. E., D. B. Parker and N. A. Cole. 2012. Potential odorous volatile organic compound emissions from feces and urine from cattle fed corn-based diets with wet distillers grains and solubles. Atmospheric Environment 60(2012):292-297.

Parker, D. B., M. B. Rhoades, N. A. Cole, V. P. Sambana. 2012. Effect of urease inhibitor application rate and rainfall on ammonia emissions from beef manure. Trans. ASABE 55(1):211-218.

Parker, D. B., W. Malone and D. Walter. 2012. Vegetative environmental buffers and exhaust fan deflectors for reducing downwind odor and VOCs from tunnel ventilated swine barns. Trans. ASABE 55(1):227-240.