

Statement of Work
Manure Technologies Expert Panel

October 29, 2014

Introduction

Animal manure has been identified as the largest source of phosphorus and the second largest source of nitrogen to the Chesapeake Bay Watershed¹. Many manure treatment technologies purport to reduce the mass loadings of these nutrients. The Chesapeake Bay Partnership's Agriculture Workgroup, Manure Treatment Subgroup identified six treatment technologies with potential to be used in the Chesapeake Bay Watershed¹: 1) anaerobic and aerobic microbial digestion, 2) chemical treatment of dry manure, 3) thermal and thermochemical treatment, 4) solid-liquid separation, 5) composting, and 6) chemical treatment of wet manure. The Chesapeake Bay Program (CBP) uses loading estimates to quantify the amount of nutrients from specific processes. Under this proposal, a panel of eight individuals will be convened to recommend estimated load reductions of nitrogen, phosphorus, and sediment resulting from implementation of specific technologies under the six broad headings identified. One of the panelists will be a representative of the CBP Watershed Technical Work Group (WTWG). A second member will represent the CBP Modeling team. This proposal recommends six experts in manure treatment technologies and environmental and water quality issues to complete the panel. This proposal was selected for funding by the Chesapeake Bay Watershed Research and Outreach Collaborative (CBW-ROC) pending final review by the CBP partnership as described in the *Protocol for the Development, Review and Approval of Loading and Effectiveness Estimates for Nutrients and Sediment Controls in the Chesapeake Bay Watershed Model² (BMP Protocol)*.

Proposed Expert Panel Membership

Douglas W. Hamilton (Expert Panel Chair)

Doug Hamilton is Associate Professor and Waste Management Specialist at Oklahoma State University. Dr. Hamilton has experience leading expert panels to create a white paper on the effectiveness of lagoons for animal waste treatment and to determine tonnage of agricultural byproducts available for biofuel feedstock in the South Central United States. He has also served on a number of expert panels including the Assessment of Ammonia Emissions from Stores of Manure in Reggio Piemonte, Italy. He has written technology assessments of solid-liquid separation and anaerobic digestion for the US Pork Center of Excellence. Dr. Hamilton will also serve as a panel expert on anaerobic and aerobic microbial digestion, solid-liquid separation, and composting.

Keri B. Cantrell

Keri Cantrell is an Environmental Engineer with the North Carolina Department of Environment and Natural Resources. Prior to working for NC DENR, Dr. Cantrell was as a consulting engineer and a Research Agricultural Engineer for the USDA ARS. Dr. Cantrell will serve as the primary expert in thermo and thermochemical processes. She

also has extensive knowledge in transformation and movement of nutrients through the solid and gaseous phases of treatment processes.

John W. Chastain

John Chastain is Professor in the School of Agricultural Forest and Environmental Sciences at Clemson University. Dr. Chastain has 25 years as an extension engineer working primarily with treatment technologies. Dr. Chastain will serve as expert in solid-liquid Separation, dry chemical treatment, and composting.

Andrea L. Ludwig

Dr. Ludwig is Assistant Professor and Extension Specialist in the Biosystems Engineering and Soil Science Department of the University of Tennessee. Dr. Ludwig's expertise is assessment of nutrient loadings to rural and urban watersheds. She has led the state oversight committee for reduction of nutrient loads in West Tennessee. Dr. Ludwig will serve as expert in determining nutrient loading of watersheds, nutrient cycling dynamics in soil and water, and microbial digestion.

Robert J. Meinen

Robert Meinen is Senior Extension Associate in the Animal Science Department at Pennsylvania State University, and has served on review panels for both the Chesapeake Bay Project and the Commonwealth of Pennsylvania. Mr. Meinen will serve as expert in animal production systems of the Chesapeake Bay Watershed. He also has extensive research and extension experience making him an expert on nutrient movement in soil and gaseous emissions from agriculture.

Jactone A. Ogejo

Jactone Ogejo is Associate Professor and Extension Specialist in the Biological Systems Engineering Department of Virginia Tech University. He has experience developing and evaluating manure treatment technologies for both the Chesapeake Bay Project and the Environmentally Superior Technologies for North Carolina Swine Farms Project. Dr. Ogejo will serve as panel expert for anaerobic and aerobic microbial digestion, liquid chemical treatments, and dry chemical treatments

Work Plan

The process to create this recommendation report will adhere to the *BMP Protocol*. Sequential steps to achieve this process are outlined as follows. A timeline to meet narrative goals is given in Table 1. The timeline is given under the assumption that the project start date will occur in December 2014.

Kick-off Meeting: A two day face-to-face meeting will take place early in the project. The meeting location will be in a central location in the Bay watershed. The *BMP Protocol* will be distributed to each panelist prior to this meeting. On the first day of the meeting, the member of CBP modeling team will brief expert panelists on the CBP model and ways the model can accommodate technologies. The expert panel will then further define the six technologies identified by the Agriculture Workgroup/Manure Treatment Subgroup¹ into specific applications of the broad technology definitions; i.e., alum or sodium bisulfite addition to dry manure. The panel will also define combinations of technologies used to treat manure; i.e., solid-liquid separation followed by fixed film

Table 1. Proposed Project Timeline

	Dec 2014	Jan 2015	Feb 2015	Mar 2015	Apr 2015	May 2015	June 2015	July 2015	Aug 2015	Sep 2015	Oct 2015
Initial face to face meeting and public forum											
Final Selection of Technologies And Technology Combinations											
Collection of Data Sets											
Data Analysis											
Task Groups send Initial assessment reports to Panel											
Second Face to Face Meeting Edit and Approve group reports											
Panel Chair Writes Draft Recommendation Report											
Review and approval of Recommendation Report Panel											
Delivery of Report to CBP Agriculture Work Group											

anaerobic digestion, struvite precipitation, and solids composting. Technologies and technology combinations will be grouped by type of manure treated.

Public Forum: An open forum will be held on the second day of the initial face to face meeting. The purpose of this forum will be to garner input, aid in data set identification, and to identify any additional technologies for consideration. This forum will be organized and advertised by CBP.

Task Groups: Following the public forum, the expert panel will narrow the list of technologies for further study based on upon their likelihood to be used in the Bay watershed. In order to facilitate efficient collection of data, the expert panel will divide itself into several smaller task groups. These groups of two or three individuals will be self-forming. As the list of technologies is reviewed, panelists will volunteer to begin searching for data on the technologies with which they are most familiar. The panel chair may also add panelists to a particular group to round out expertise of the group. Task groups will remain intact until the recommendation report is written.

Panel Communication: The panel chair will work with the Project Coordinator to establish a common virtual space where panelists can share information and data. In addition to face to face meetings, panelists will communicate in monthly conference calls.

Gather Data and Selection of Final Technologies: Task groups will gather data sets for the selected technologies and rank their validity using criteria of Table 1 of the *BMP Protocol*. Technologies with limited valid data sets will be deemphasized. Those technologies not chosen for complete analysis may be evaluated to provide incremental recommendation according to the *BMP Protocol*.

Analysis of Data: Using data sets and best professional judgment of the panelists, selected technologies and combinations of technologies will be analyzed to determine flow path of measured constituents (N, P, solids), transformation of constituents, mass reduction of influent constituents and partition into effluent liquid, gaseous, and solid streams. These data will be used to construct a table of recommended nitrogen, phosphorus, and sediment loading reduction for each technology and combination of technologies. At this time, task groups will also identify ancillary benefits and negative consequences of each technology. Each group will prepare a written report giving a detailed definition of the technology and results of data analysis. This report will also include a list of references and a discussion of how each reference was considered. The discussion will also consider conditions under which the technology will not work, start-up time for the technology, and maintenance and upkeep requirements of the technology.

Consensus of Results: A second face to face meeting will be held in which each technology task group will orally present the reports created during the data analysis phase. Draft reports will be available to all panelists before this meeting on the common virtual space. The panel will evaluate and provide feedback to each task group. Dissenting opinions of panelists will be noted and preparation will be made to add these dissenting views as an appendix to the recommendations report. The second face to face meeting will be held in a locale conducive to completing the task.

Preparation of Draft Report: The Panel Chair, working with the Coordinator will coalesce the task group reports into a draft final report. Panel chair will send draft report to entire panel via the common virtual space. Panelists will return written comments to chair in one month. The modeling team representative on the panel will work with the WTWG representative to develop the draft Technical Appendix for Scenario Builder.

Approval of Final Recommendation Report: After one month's review time, the expert panel will approve or disapprove of the document via voice vote in a conference call. In the case of non-unanimity, a separate dissenting will be attached as an appendix. Panel chair will then forward the report to the Agriculture Work Group as prescribed by the *BMP Protocol*.

References

1. *Recommendations for the Manure Treatment Technologies Expert Panel.* July 14, 2014. Manure Treatment Technology Subgroup of Chesapeake Bay Program Partnerships Agriculture Workgroup.
2. *Protocol for the Development, Review, and Approval of Loading and Effectiveness Estimates for Nutrient and Sediment Controls in the Chesapeake Bay Watershed Model.* July 14, 2014. Chesapeake Bay Program Water Quality Goal Implementation Team.

Douglas W. Hamilton, Ph.D. P.E.

Associate Professor and Extension Waste Management Specialist.
Biosystems and Agricultural Engineering. Oklahoma State University
Stillwater, OK 74078

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405-744-7089

<http://osuwastemanage.bae.okstate.edu> www.youtube.com/osuwastemanagement

EDUCATION

Ph. D. Agricultural Engineering Pennsylvania State University. 1992
M.S. Agricultural Engineering Iowa State University. 1985
B.S. Agricultural Engineering University of Arkansas. 1983

PROFESSIONAL EXPERIENCE

Associate Professor	Biosystems and Agricultural Engineering and Extension Waste Management Specialist	Oklahoma State University 2000-present
Assistant Professor	Biosystems and Agricultural Engineering and Extension Waste Management Specialist	Oklahoma State University 1995-2000
Assistant Professor	Biosystems and Agricultural Engineering and Extension Soil and Water Specialist	University of Tennessee. 1992-1995.
Inspection Engineer II	Department of Pollution Control and Ecology	State of Arkansas 1985-1988

PROFESSIONAL REGISTRATION

Tennessee: PE # 00101266

AWARDS

Blue Ribbon ASABE Education Aids Competition. 2013, 2011, 2002 and 2000

Secretary of Agriculture Honor Award. 2002. Leadership of Oklahoma Poultry Waste Management Education Team.

Certificate of Achievement USDA-CSREES. 2002. Leadership of Oklahoma Poultry Waste Management Education Team.

PROFESSIONAL ASSOCIATIONS

American Society of Agricultural and Biological Engineers
Water Environment Federation
Air and Waste Management Association

ELECTED SCIENTIFIC AND SERVICE COMMITTEES.

Board of Directors, North American Manure Expo, Inc. 2014-2017.

Stakeholders Advisory Group for the Growth Promoters, Wind, and Human Ecological Health USDA-NRI Integrated Project at Texas Tech University. 2010-2013.

Manure and Byproduct Utilization. USDA-ARS/CSREES. St Louis, MO. 2008.

Water Quality Research Summit. National Pork Board. Des Moines, IA 2008.

OK Delegation to the First International Forum on Permaculture and Intensive Agriculture. Facultad de Zootecnia, UA Chihuahua, Mexico. 2004.

Assessment of Ammonia Emissions from the Stores of Animal Wastes in Reggio Piemonte. Univerista degli Studi di Torino, Italy. 2003-2004.

SELECTED PUBLICATIONS

Hamilton, D.W. and M.T. Steele. 2014. Operation and performance of a farm-scale anaerobic sequencing batch reactor (ASBR) treating dilute swine manure. *Transactions of ASABE*. 57(5) in press.

Hamilton, D.W. 2014. *Solid State Anaerobic Digestion*, BAE-1764. Stillwater, OK: Oklahoma Cooperative Extension Service.

Hamilton, D.W. 2014. *Particle Size Distribution of Manure and Byproduct Slurries*, BAE-1765. Stillwater, OK: Oklahoma Cooperative Extension Service.

Hamilton, D.W. 2014. *Anaerobic Digestion of Animal Manure Series: Understanding the Basic Processes*, BAE-1747. *Types of Digesters*, BAE-1750. *Methane Production Potential of Waste Materials*, BAE 1762. *Inhibitory and Toxic Materials*, BAE 1763. Stillwater, OK: Oklahoma Cooperative Extension Service.

Lim, T.T., G. Arnold, A. Douridas, K. Erb, T. Bay, C.E. Henry, C.E., R.E. Meinen, and **D.W. Hamilton**. 2013. North American Manure Expo: Creating a permanent, sustainable base for hands-on manure applicator education, final report. Great Lakes Water Quality Program.

Hamilton, D.W. 2013. *What Every Pork Producer Should Know About Anaerobic Digestion*. Factsheet in Pork Information Gateway (PIG) of the US Pork Center for Excellence. <http://www.porkgateway.org/PIGLibraryDetail/PF/2072.aspx>

Hamilton, D.W. 2010. *Solids Separation in Swine Manure Handling Systems*. eXtension Hogs, Pigs, and Pork. <http://www.extension.org/pages/27470/solids-separation-in-swine-manure-handling-systems#.Uyyb7ahdV0M>

Hamilton, D.W., M. Hubert, M. Kerley, N. Meister, A. Parks, J. Payne, and J.M Sweeten. 2009. Agricultural industries byproduct workgroup results, pp 37-44. In, *Feedstocks Workshop Report*. Stillwater, OK: South Central Region Sun Grant Center.

Hamilton D.W., C.D. Fulhage, B.Z. Fathepure, W. D Clarkson, and J.L. Lalman. 2006. Treatment lagoons for animal agriculture. Pp.547-547. In: *Animal Agriculture and the Environment. National Center for Manure and Animal Waste Management White Papers, Pub No 913C0306*. St Joseph, MI. ASABE.

Keri B. Cantrell, PE

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EDUCATION

Doctor of Philosophy in Biosystems Engineering, Clemson University, Clemson, SC, 2006.
Masters of Science in Biosystems Engineering, Clemson University, Clemson, SC, 2002.
Bachelors of Science in Chemical Engineering, minor in Sociology, Clemson University, Clemson, SC, 2001.

EXPERIENCE

KBC Engineering & Consulting, Concord, NC

2014 – Present

Principal Environmental Engineer

- Collaborating with USDA-ARS on two biochar projects developing customized biochars for target applications.

USDA Agricultural Research Service (ARS), Florence, SC

2006 - 2013

Coastal Plains Soil, Water and Plant Research Center

Research Agricultural Engineer GS-13

- Contributed research to national project plan designed to manage livestock operations and their wastewater to reduce environmental releases of odors, pathogens, contaminants, as well as nutrient recovery and recycle.
 - Focused personal research on manure-to-energy (thermal) treatment practices and their byproduct applications.
- Published more than 30 peer-reviewed manuscripts in 10+ soil, environmental, and engineering journals.
- Developed new knowledge and methods for using waste-to-energy technologies and value-added energy by-products in waste/wastewater treatment designs:
 - Advanced the use of manures as bioenergy feedstocks in pyrolysis and gasification systems;
 - Modeled methane production from manures through wet gasification;
 - Improved quality of manure feedstocks with solid-liquid separation techniques;
 - Tested pilot pyrolysis systems converting manures and plasticulture waste into biochar, syngas, and electrical energy production.
- Investigated the production and field applications of designer biochars (carbon residuals):
 - Projects included mined field reclamation, *E. coli* movement, phosphorus recycle, heavy metal immobilization, storm water remediation, soil fertility impacts and activated carbon adsorption.
- Consulted NC and VA NRCS staff and industry on suitability of pyrolysis technology addressing biochar phosphorus availability and runoff in the Chesapeake Bay Watershed.

Clemson University, Clemson, SC

2003-2006

Agricultural and Biological Engineering Department

Doctoral Graduate Research Assistant

- Patented CO₂-based fungal lipid supercritical fluid extraction (SFE) application via CO₂-explosion pretreatment technique; U.S. Patent No. 8,148,559.

- Dissertation: Integrated Bioprocessing of *Pythium irregulare* to Obtain PUFA-rich Oil.

Clemson University, Clemson, SC
Agricultural and Biological Engineering Department
Masters Graduate Research Assistant

2001 - 2002

- Thesis: Treatment of lagoon sludge and liquid animal manure utilizing geotextile filtration.
- Designed and implemented experiments for treatment of lagoon sludge and liquid manure using the liquid-solid separation technique of geotextile filtration.

HONORS AND AWARDS

PE license in NC (2013); American Society of Agricultural and Biological Engineers (ASABE) Superior Paper Award (2011): "Thermogravimetric characterization of irrigated bermudagrass as a combustion feedstock".

PROFESSIONAL MEMBERSHIPS

ASABE (2001-2002, 2006-Present); member, ASABE T-11 Energy Committee (2010-Present; chair 2010-2012); ASABE SE 414 Renewable Power Generation Committee (2012-Present; officer 2012-Present)

SELECTED PUBLICATIONS

Ro, K.S., **Cantrell, K.B.**, et al. Catalytic wet gasification of municipal and animal wastes. Ind. Eng. Chem. Res. 46: 8839. 2007.

Cantrell, K.B., Ducey, T., et al. Livestock waste-to-bioenergy generation opportunities. Biores. Technol. 99: 7941. 2008.

Ro, K.S., **Cantrell, K.B.**, et al. High-temperature pyrolysis of blended animal manures for producing renewable energy and value-added biochar. Ind. Eng. Chem. Res. 49:10125. 2010.

Uchimiya, S.M., **Cantrell, K.B.**, et al. Retention of heavy metals in a Typic Kandudult amended with five varieties of manure-based biochars. J. Environ. Qual. 41:1138. 2012.

Spokas, K.A., **Cantrell, K.B.**, et al. Biochar: A synthesis of its agronomic impact beyond carbon sequestration. J. Environ. Qual. 41:973. 2012.

Cantrell, K.B., Hunt, P.G., et al. Impact of pyrolysis temperature and manure source on physicochemical characteristics of biochar. Biores. Technol. 107:419. 2012.

Cantrell, K.B., Ro, K.S., et al. Green farming systems for the Southeast USA using manure-to-energy conversion platforms. J. Renew. Sustain. Energ. DOI: 10.1063/1.3663846. 2012.

Novak, J.M., **Cantrell, K.B.**, et al. Designing relevant biochars as soil amendments using lignocellulosic and manure-based feedstocks. J. Soils Sedim. 14:330. 2013.

Novak, J.M., Spokas, K.A., **Cantrell, K.B.**, et al. Effects of biochars and hydrochars produced from lignocellulosic and animal manure on fertility of a Mollisol and Entisol. Soil Use Manage. 30:175. 2014.

Cantrell, K.B., Martin, J., et al. Poultry litter and switchgrass blending for biochar production. Trans ASABE. 57(2):543. 2014.

Curriculum Vitae

John P. Chastain, Ph.D.

September 2014

PERSONAL DATA

School of Agricultural, Forest, and Environmental Sciences
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Clemson University
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EDUCATION

<u>Earned Degrees</u>	<u>University</u>	<u>Date of Award</u>
Ph.D. Agricultural Engineering (Biosystems Engineering emphasis area)	University of Kentucky	December 1991
MS Agricultural Engineering	University of Kentucky	May 1987
BS Agricultural Engineering	University of Georgia	June 1982

RELEVANT EXPERIENCE

7/1/2013 – 6/30/2011: Professor and Extension Agricultural Engineer, Clemson University
7/2001 – 6/2007: Associate Professor and Extension Agricultural Engineer, Clemson University
8/18/95 – 7/2001: Assistant Professor and Extension Agricultural Engineer, Clemson University
12/91 – 9/15/95: Assistant Professor and Extension Agricultural Engineer, University of Minnesota.

Publications Related to Solid-Liquid Separation

Chastain, J.P. 1999. Effects of Solid-Liquid Separation on Phosphorous Management. Proceedings of the Southeast Regional Extension Water Quality Conference, Raleigh, NC, April 19-20.

Chastain, J.P. and J.A. Darby, Jr. 2000. A Thickening Process for Reducing the Cost of Utilizing Dairy Lagoon Sludge. In: J.A. Moore (ed), Animal, Agricultural and Food Processing Wastes: Proceedings of the Eighth International Symposium, Des Moines, IA, Oct. 9-11, ASAE, St. Joseph, MI, pp 694-701.

Chastain, J.P., W.D. Lucas, J.E. Albrecht, J.C. Pardue, J. Adams, III, and K.P. Moore. 2001. Removal of solids and major plant nutrients from swine manure using a screw press separator. Applied Engineering in Agriculture, 17(3): 355-363.

Chastain, J.P., M.B. Vanotti, and M.M. Wingfield. 2001. Effectiveness of liquid-solid separation for treatment of flushed dairy manure: a case study. Applied Engineering in Agriculture, 17(3): 343-354.

Chastain, J.P. and M.B. Vanotti. 2003. Correlation Equations to Predict the Solids and Plant Nutrient Removal Efficiencies for Gravity Settling of Swine Manure. In: R.T. Burnes (ed), Animal, Agricultural and Food Processing Wastes IX : Proceedings of the Ninth International Symposium, Research Triangle Park, NC, Oct. 12-15, ASAE, St. Joseph, MI, pp 487-495.

Coloma, A., J.P. Chastain, and K.P. Moore. 2004. Fractionation of Solids, Plant Nutrients, and Carbon as a Result of Screening Broiler Litter. Paper No. 044086. St. Joseph, Mich.: ASABE.

Thomas, C.N., J.P. Chastain, T.O. Owino, W.L. Bauerle, and K.P. Moore. 2004. Utilization of Brick Plant Air Scrubber By-Product to Enhance Settling and pH Adjustment of Anaerobic Dairy Lagoon Sludge. Paper No. 044058. St. Joseph, Mich.: ASABE.

Chastain, J.P., K.B. Cantrell, and K.P. Moore. 2005. Composition and Settling Characteristics of Milking Center Wastewater: A Case Study. Paper No. 054102. St. Joseph, Mich.: ASABE.

Cantrell, K.B., J.P. Chastain, and K.P. Moore. 2008. Geotextile filtration performance for lagoon sludges and liquid animal manures dewatering. Transactions of the ASABE, 51(3):1067-1076.

Chastain, J.P. 2009. Field Evaluation of a Two-Stage Liquid-Solid Separation System at a California Dairy. Paper No. 096716. St. Joseph, Mich.: ASABE.

Garcia, M.C., A.A. Szogi, M.B. Vanotti, J.P. Chastain, and P.D. Miller. 2009. Enhanced solid-liquid separation of dairy manure with natural flocculants. Bioresource Technology, 100(22):5417-5423.

Chastain, J.P. 2011. Hindered Settling of Animal Manure. Paper No. 1111188. St. Joseph, Mich.: ASABE.

Porter, J.P., and Chastain, J.P. 2013. Overview of Solid-Liquid Separation Alternatives for Manure Handling and Treatment Document, In Proceedings of the National Extension Conference: Waste to Worth – Spreading Science & Solutions, April 1-5, Grand Hyatt Hotel, Denver CO. Available at: <http://www.extension.org/pages/67673/overview-of-solid-liquid-separation-alternatives-for-manure-handling-and-treatment-document>.

Chastain, J. P., 2014. Solid-Liquid Separation Alternatives for Manure Handling and Treatment. This 309 page manuscript will be published by USDA-NRCS as part of their Environmental Engineering Series. In the final stages of editing by USDA-NRCS.

Publications Related to Anaerobic Treatment and Combustion of Litter

Chastain, J.P., D.E. Linvill, and F.J. Wolak. 1999. On-Farm Biogas Production and Utilization for South Carolina Livestock Operations. Final report published by the Southeastern Biomass Energy Project, TVA, June 4, Muscle Shoals, Alabama, 129 pp.

Chastain, J.P. and D.E. Linvill. 1999. A Model of the Operating Characteristics of Covered Lagoon Digesters for Swine and Dairy Manure. Paper No. 994045. St. Joseph, Mich.: ASABE.

Chastain, J.P. 2006. Estimation of Sludge Accumulation in Lagoons. Paper No. 064114. St. Joseph, Mich.: ASABE.

Chastain, J.P., A. Coloma-del Valle, and K.P. Moore. 2012. Using Broiler Litter as an Energy Source: Energy Content and Ash Composition. Applied Engineering in Agriculture, 28(4):513-522.

Chastain, J.P., and J.P. Porter. 2013. Benefits of Using Liquid-Solid Separation with Manure Treatment Lagoons, In Proceedings of the the National Extension Conference: Waste to Worth – Spreading Science & Solutions, April 1-5, Grand Hyatt Hotel, Denver CO. Available at: <http://www.extension.org/pages/67583/benefits-of-using-liquid-solid-separation-with-manure-treatment-lagoons>.

Publications Related to Compost Production and Use

Chastain, J.P., C.C. Frase, and K.P. Moore. 2006. Composition of Animal Manure Compost and Utilization Implications. Paper No. 064054. St. Joseph, Mich.: ASABE.

Massey, H.F., J.P. Chastain, T.O. Owino, R.F. Polomski, and K.P. Moore. 2011. Chemical and Physical Properties of Potting Media Containing Varying Amounts of Composted Poultry Litter. Paper No. 1110935. St. Joseph, Mich.: ASABE.

Chastain, J.P., P.A. Rollins, and K.P. Moore. 2013. Composting of Turkey Brooder Litter in South Carolina: An On-Farm Demonstration Project. Journal of Agricultural Systems, Technology, and Management, 25:36-50.

Andrea L. Ludwig, PhD, EIT

Assistant Professor and Extension Specialist, Biosystems Engineering & Soil Science Department,
University of Tennessee

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aludwig@utk.edu (preferred contact)

EDUCATION

PhD Biological Systems Engineering, Virginia Tech, Blacksburg, VA, June 2010

Advisor: W. Cully Hession, PhD, PE. Dissertation: Constructed Floodplain Wetland Effectiveness for Stormwater Management.

MS Environmental Engineering, University of Arkansas, Fayetteville, AR, August 2006.

Advisor: Marty D. Matlock, PhD, PE, CSE. Thesis: Periphytic Algae Nutrient Limitation in the Beaver Lake Reservoir, Northwest Arkansas, 2005-2006.

BS Biological Engineering, University of Arkansas, Fayetteville, AR, August 2004.

Ecological Engineering Emphasis.

EXPERIENCE

2010-Present **Assistant Professor and Extension Specialist**, Biosystems Engineering and Soil Science Department, The University of Tennessee – Knoxville. Extension focus: Stormwater management. Research focus: Ecological restoration and water quality best management practices.

2006-2010 **Graduate Research/Teaching Assistant**, Department of Biological Systems Engineering, Virginia Tech. Assistantship funding: Opequon Targeted Watershed, Chesapeake Bay Program, National Fish and Wildlife Federation. Research topics: design and evaluate innovative best management practices for stormwater treatment.

2004-2006 **Graduate Research/Teaching Assistant**, Department of Biological Engineering, University of Arkansas. Assistantship funding: L'Anguille River Watershed Decision Support System Development, Arkansas Nonpoint Source Management Plan Development, Evaluating Primary Productivity in the White River System, National Wadeable Streams Assessment.

UNIVERSITY/EXTENSION COURSE DEVELOPMENT

Rain Gardens for Tennessee (UT Extension Training Series)

Special Topics: Stream Restoration Design (Co-Instructor, University of Tennessee)

Introduction to Green Engineering, Instrumentation in Biological Systems Engineering (TA, Virginia Tech)

Introduction to Engineering Fundamentals (TA, University of Arkansas)

LICENSURE AND CERTIFICATION

Engineer Intern # 6804 AR, Dec 2004-present.

Future Professoriate Graduate Certificate, Graduate Education and Development Institute, Virginia Tech, May 2010. Selected for Global Perspectives Program, Switzerland.

REFEREED PUBLICATIONS

Ludwig, A. and W.C. Wright (2014). Integrated constructed wetlands for treatment of dairy operation runoff in Eastern Tennessee during first year establishment. *Ecological Engineering* (In Press) DOI: 10.1016/j.ecoleng.2014.07.077

Ludwig, A., M.D. Matlock, B.E. Haggard, and I. Chaubey (2012). Limiting factors on periphyton and maximum potential productivity in the Beaver Lake Basin, USA. *Journal of the American Water Resources Association*, 48 (5), 896-908.

Ludwig, A., M.D. Matlock, B.E. Haggard, M. Matlock, and E. Cummings (2008). Identification and evaluation of nutrient limitation on periphyton growth in headwater streams in the Pawnee Nation, Oklahoma. *Ecological Engineering* 32, 178-186.

OTHER PUBLICATIONS

Backyard Science Technology Engineering and Mathematics Curriculum, Tennessee 4-H.
Rainwater: Your Liquid Asset. UT Extension Publication W 300. 2013.
Tennessee Storm-SMART Glossary of Terms for Communities. UT Extension Publication. W301. 2013.

CURRENT COLLABORATIVE RESEARCH AND EXTENSION EFFORTS

Stormwater Management Assistance Research and Training Center – research and extension center funded through UT AgResearch and Extension

Effective Urban Streambank Stabilization Practices in Oostanaula Creek Watershed – demonstration project implementation funded through EPA319 program.

Constructed Stormwater Wetlands at the Little River Animal & Environmental Research Unit– research funded by UT AgResearch and Extension

Tennessee Smart Yards – state-wide educational program funded through EPA319 program

Watershed Academy – regional educational program funded through the Southern Regional Water Quality Program, United States Department of Agriculture

PROFESSIONAL AND CIVIC SERVICE

American Ecological Engineering Society – Past Secretary (2011-2013), Conference Planning Committee

West Tennessee Nutrient Reduction Strategy State-Led Oversight Committee

Tennessee Stormwater Association – Education and Professional Committee Member

Tennessee American Water Resources Association – Current Secretary (2013-2015)

Faculty Advisor, Student Chapter of the American Water Resources Association at UTK

City of Knoxville Environmental Appeals Board Member

AWARDS

2013 Outstanding Service Faculty Award, Biosystems Engineering & Soil Science Department

2013 Outstanding New Extension Worker Award, UT Extension

Robert J. Meinen
303 ASI Building
University Park, PA 16802
(814) 865 – 5986
rjm134@psu.edu

EDUCATION

The Pennsylvania State University

- BS, Agricultural Systems Management and Technologies, 1993
- MS, Animal Science, 2008
- PhD student, Soil Science, 2008 - present

WORK EXPERIENCE

The Pennsylvania State University

2000 - present

Senior Extension Associate, Department of Animal Science, University Park, PA

Pennsylvania Act 49 Commercial Manure Hauler and Broker Certification Program

- Lead coordinator, curricula developer, and educator of certification programs.

North American Manure Expo (NAME)

- Secretary/Treasurer of the NAME Board of Directors.
- Co-chair of 2015 NAME in Chambersburg, PA. The Manure Expo has been hosted previously in PA (chairman), WI, MN, MI, OH, IA, NE, ON (Canada) and MO (2014).

Pennsylvania Nutrient Management Advisory Board

- Subcommittee participant for development of PA DEP Manure Management Manual, Commercial Manure Hauler Certification Program and Odor Management Plans.

PA DEP Manure Management Manual

- Development of manual and leader of educational program.

ANSC/AGECO/SOILS 418; Nutrient Management in Agricultural Systems

- Co-Instructor of Penn State Nutrient Management Planning course.

USDA-NRCS Feed Management Subcommittee of the PA State Technical Committee

- Exploration of potential environmental solutions through Feed Management.

2010 Chesapeake Manure Summit

- Key committee member of this forum which hosted 60 legislative, agency, policy, and educational decision makers from the entire Bay region to explore the future of environmental policy pertaining to livestock and agricultural nutrient pollution.

Pine Hurst Acres Swine Manure Digester

- Investigator and adviser for innovative swine manure digestion and methane cogeneration project. Animal behavior, air quality and financial research.
- Initiated Pennsylvania's first farm-level carbon credit trading.

Pennsylvania Act 38 Odor Management Plans

- Member of both Technical Workgroup and Interagency Odor Workgroup, which advise program and regulation development.
- Educator for Odor Management Plan Writer Continuing Education Program.

PennAg Industries Manure Hauler and Broker Council

- Key catalyst for 2004 council formation and council adviser since its establishment.

Food and Agricultural Organization of the United Nations

- Co-author of swine and poultry sections of comprehensive review project entitled *Regionally Appropriate and Effective Livestock Non-CO₂ Mitigation Packages*.

ANSC 306; Swine Production and Management

- Co-instructor of this course that covers all aspects of the swine industry.

ANSC 100; Introduction to Animal Industries

- Developed environmental curricula for this Penn State online course.

Composting of Agricultural Wastes

- Deliver extension programming with emphasis on livestock mortality composting.

eXtension / Livestock & Poultry Environmental Learning Center

- Member of the "Ask the Expert" team of this national educational web-based network.

Air Quality Subcommittee to NRCS State Technical Advisory Committee

- Provide technical guidance on agricultural air quality issues, technologies and funding.

Manure Du Jour Webinar Series

- Co-founder, committee member, speaker, and host for educational webinar series.

Pennsylvania Environmental Agricultural Conservation Certification of Excellence (PEACCE) program (inactive since 2009)

- President of PEACCE Board. PEACCE certified livestock farms that met environmental compliance and stewardship criteria. Eighty-six farms in 17 PA counties were certified.

Pennsylvania Environmental Awareness Course

- Over 1,200 producers and students completed the course (2000-2009).

Jamaican Digester Project

- Advisory role in educational exchange program between Penn State University's College of Engineering and the University of Technology, Kingston, Jamaica.

PhD Research

- Striving towards Soil Science PhD while a full-time university staff member.
- Research concentrates on development of a soil sampling protocol for the Pre-Sidedress Nitrate Test on lands planted in corn with banded manure injection.

Grant Participation at Penn State (Selected)

- Manure Gas Risks Associated with Gypsum Bedding at Dairy Farms (NRCS-CIG, funded 2013) – Outreach, Expertise and Research teams.
- Mitigation of Greenhouse Gas Emissions in Livestock Production; A review of technical options for non-CO₂ emissions (FAO of the United Nations, funded 2011) – Co-Author.
- Upper Kishacoquillas Creek Nutrient and Sediment Management Project (NFWF, funded 2011) – Outreach and Expertise teams.
- Promoting Adoption of Innovative Conservation Cropping System on Livestock Farms (NRCS-CIG, funded 2009) – Co-PI. Leadership, Farm Research and Expertise teams.
- Sustainable Cropping Systems for Dairy Farms in the Northeastern US (NESARE, funded 2008) – Farm Research and Expertise teams.
- Conewago Creek Conservation Initiative (NFWF, funded 2009) – Expertise team.
- Chesapeake Dairy Sustainability Project (NFWF, funded 2008) – Expertise team.
- Schuylkill Action Network (Partnership of the Delaware Estuary, funded 2006) – Outreach and Field Implementation teams.

Purina Mills, Inc.

1994 - 2000

Farm Manager, Wide Awake Farm, Clearville, PA (Management training Milton, DE, 1994)

Environmental Stewardship.

- Winner of 1999 Pork Industry Environmental Stewardship Award.
- Implementation of industry leading environmental stewardship program at 1,250 sow farrow-to-feeder farm and gilt multiplier for PIC stock.

Production.

- Recognized as 'Top Producing Sow Herd' by Purina Mills in 1998 and 1999.
- Received PIC's Gold Performance Award in 1997, 1998 and 1999.

SELECT PUBLICATIONS

- R. J. Meinen, K. B. Kephart, R. E. Graves. Economic Feasibility and Evaluation of a Novel Manure Collection and Anaerobic Digestion System at a Commercial Swine Finisher Enterprise. Journal of Biomass and Bioenergy. February 2014.
- F. Montes, R. Meinen, C. Dell, A. Rotz, A. N. Hristov, J. Oh, G. Waghorn, P. J. Gerber, B. Henderson, H. P. S. Makkar and J. Dijkstra. Mitigation of methane and nitrous oxide emissions from animal operations: II. A review of manure management mitigation options. Journal of Animal Science. December 2013.
- P. J. Gerber, A. N. Hristov, B. Henderson, H. Makkar, J. Oh, C. Lee, R. Meinen, F. Montes, T. Ott, J. Firkins, A. Rotz, C. Dell, A. T. Adesogan, W. Z. Yang, J. M. Tricarico, E. Kebreab, G. Waghorn, J. Dijkstra, and S. Oosting. Technical options for the mitigation of direct methane and nitrous oxide emissions from livestock: a review. Animal. July 2013.
- A. N. Hristov, J. Oh, C. Lee, R. Meinen, F. Montes, T. Ott, J. Firkins, A. Rotz, C. Dell, A. Adesogan., W. Yang, J. Tricarico, E. Kebreab, G. Waghorn, J. Dijkstra and S. Oosting. Mitigation of Greenhouse Gas Emissions in Livestock Production: A review of technical options of non-CO₂ emissions. Food and Agriculture Organization (FAO) of the United Nations. Rome 2013.
- A. Swinker, S. Worobey, H. McKernan, R. Meinen, D. Kniffen, D. Fould, M. Hall, J. Weld, F. Schneider, A. Burk and M. Brubaker. Profile of the Equine Industry's Environmental, Best Management Practices and Variations in Pennsylvania. Journal of Equine Veterinary Science. January 2011.

Jactone A. Ogejo, Ph.D., P.E.

EDUCATION

University of Illinois, Urbana, IL	Ph.D.	Agricultural Engineering
University of Illinois, Urbana, IL	M.S.	Agricultural Engineering
University of Nairobi, Kenya	B.S.	Agricultural Engineering

LICENSURE

Professional Engineer, State of North Carolina (License No. 028310).

PROFESSIONAL EXPERIENCE

Jul 2011 to Present	Assoc. Professor and Extension Specialist, Biological Systems Engineering Department, Virginia Tech, Blacksburg VA.
Jan 2005 to Jun 2011	Assist. Professor and Extension Specialist, Biological Systems Engineering Department, Virginia Tech, Blacksburg VA.
Mar 1999 to Dec 2004	Research Associate, Biological and Agricultural Engineering Department, North Carolina State University, Raleigh, NC.
Jun 1997 to Feb 1999	Assistant Researcher, Biosystems and Agricultural Engineering Department, Oklahoma State University, Stillwater, OK.

RESEARCH AND OUTREACH INTEREST AND EXPERIENCE

Dr. Ogejo's research focuses the management and utilization of byproducts from agricultural production and food processing industries with a goal to minimize their environmental pollution potential. The emphasis of his work is on energy recovery from manure and other organic materials using anaerobic digestion technology; nitrogen and phosphorus recovery using combinations of chemical, physical, and biological processes; development of mitigation strategies to minimize emissions of pollutants from animal feeding operations; and development of process based models to estimate gaseous emissions from animal feeding operations. He has experience on implementing and evaluating on farm anaerobic digesters and manure treatment technologies, for examples, Dairy Energy Inc., anaerobic digester located at the VanderHyde dairy in Virginia) and implementation of the environmentally superior technologies for swine farms in North Carolina (http://www.cals.ncsu.edu/waste_mgt/smithfield_projects/smithfieldsite.htm). His outreach responsibilities include: develop and disseminate education programs on best management practices to improve manure handling, safety, use, and environmental stewardship; develop and implement improved on farm based cost-effective manure treatment technologies to mitigate pollution potential due to manure use and to enhance their adoption.

PROFESSIONAL SERVICE

Dr. Ogejo is a member, American Society of Agricultural and Biological Engineers and serves on committees dealing with animal manure management and air quality. He is also a member of a Multistate/Regional project S1032: Toward sustainable production of animal protein. He has served in many leadership roles in these professional organizations.

SELECTED PERTINENT PUBLICATIONS

- Stephenson K., A. Latane, G. Evanylo, J. Ogejo, D. Beegle, C. Abdalla, J. Pease, J. McGrath, J. Ignosh, T. Richard. 2013. Technical Analysis for Nutrient Crediting of Manure Conversion Technologies", 66pp. Mid-Atlantic Water Program
- Collins E., J. Ogejo, A. King. 2012. Evaluation of an On-Farm Two Stage Anaerobic Digester for Biogas/Biomethane production from Dairy Manure. ASABE Paper Number: 121337028. St. Joseph, Mich.: ASABE
- Pease J., J. Arogo, R. Maguire, D. Bosch, J. Farris, J. O'Neill. 2012. Evaluating Net Benefits/Impacts of a Shenandoah Valley Poultry Litter to Energy Power Plant," report to Virginia Department of Environmental Quality, contract 15326
- Shen, Y., J.A. Ogejo, and K.E. Bowers. 2011. Abating the effects of calcium in the precipitation of struvite from liquid dairy manure. Trans. of the ASABE 54(1): 325-336
- Ogejo, J.A., S. Wildeus, P. Knight, and R.B. Wilke. 2010. Evaluating goat and sheep manure production and their nutrient contribution in the Chesapeake Bay watershed. Applied Engineering in Agriculture 26(6): 1061-1065
- Ogejo, J.A. and L. Li. 2010. Enhancing biomethane production from flush dairy manure with turkey processing wastewater. Applied Energy 87: 3171-3177
- Westerman, P.W., J.A. Ogejo, and G. Grabow. 2010. Swine anaerobic lagoon nutrient concentration variation with season, lagoon level, and rainfall. Applied Engineering in Agriculture 26(1): 147-152
- Ndegwa, P.M., A.N. Hristov, J. Arogo, and R.E. Sheffield. 2008. A review of ammonia mitigation techniques for concentrated animal feeding operations. Biosystems Engineering 100: 453-469
- DeBusk, J.A., J.A. Ogejo, K.F. Knowlton, N.G. Love. 2008. Chemical phosphorus removal for separated flushed dairy manure. Applied Engineering in Agric. 24(4): 499-506
- Shah, S.B., P.W. Westerman, J. Arogo. 2006. Measuring ammonia concentrations and emissions from agricultural land and liquid surfaces: a review. J. Air & Waste Manage. Assoc. 56(7):945-960
- Westerman, P.W. and J. Arogo. 2005. On Farm Performance of two solids-liquids separation systems for flushed swine manure. Applied Engineering in Agriculture 21(4): 707-717
- Westerman, P.W., J. Arogo. 2005. Performance of a pond aeration system for treating swine anaerobic swine lagoon effluent. Applied Engineering in Agriculture 21(3): 505-516