PROCEEDINGS

2004 National Poultry Waste Management Symposium

Legal Implications of the Clean Air and Water Acts

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Community Relations

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Air Quality and Emissions

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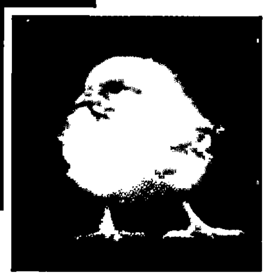
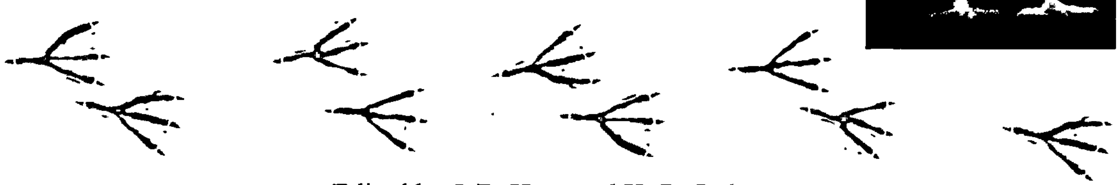
CAFO Compliance Around the County





Edited by J. B. Hess and K. D. Roberson

Proceedings

2004 National Poultry Waste Management Symposium

"Balancing Economic and Environmental Issues"
October 24-26, 2004

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Edited by:

Joseph B. Hess
Department of Poultry Science
Auburn University

Kevin D. Roberson
Department of Animal Science
Michigan State University

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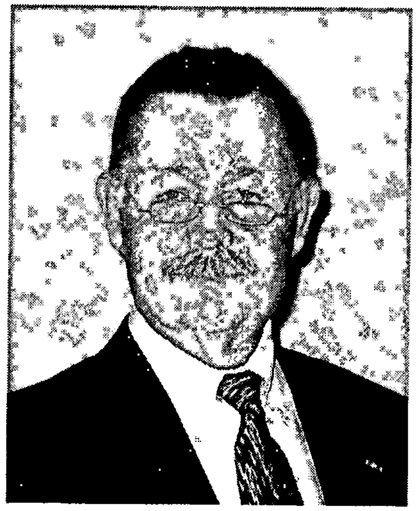

Dr. Lewis E. Carr

Dr. Lewis Carr, known as "Lew" to his colleagues, has been involved in poultry research and extension work for over 30 years. Dr. Carr received his B.S. degree in 1963 from Virginia Polytechnic Institute and State University (VPI). From 1965 through 1968, Lew served in the Combat Engineers in Vietnam as a Platoon Leader, Assistant Operations and Training Officer, Company Executive Officer, and Company Commander. He also served as an instructor in the Army Engineer School. In 1969, he returned to VPI to complete his M.S. Degree in Agricultural Engineering. From 1970 to 1972, he worked for Purina Chows and Health Products in promotion, sales and distribution. Afterwards, Lew joined the Agricultural Engineering Department at the University of Maryland where he later received his Ph.D. and has been with the University of Maryland since 1973.

Dr. Carr has been stationed at the Lower Eastern Shore Research and Education Center, and his responsibilities include: engineering research, teaching and extension in poultry production, processing and waste management. He has conducted research and outreach programs on energy conservation, watering systems, broiler environmental issues, ammonia release and control, use of broiler litter as ruminant feed, agricultural safety and health, Salmonella reduction in poultry production systems, and the use of automation and robotics in poultry processing. Lew is perhaps best known worldwide for his work with composting poultry, agriculture and municipal residuals into environmentally-friendly products. He was instrumental in helping develop procedures for dead bird mortality composting, has provided regional grower training on mortality composting procedures, and has provided 13 years of leadership for Maryland's Better Composting School. He is regularly invited to other countries, including China, Russia, Australia, Mexico, Canada, The Netherlands, England, and others, to share his expertise in waste management. As part of his research and extension efforts, Dr. Carr has published or presented over 300 articles and papers.

Lew's family plays a central role in his life. His wife, Meredythe, her mother, his two daughters, Melissa and Mimi, his son Michael, and his three grandchildren provide inspiration to all of his endeavors.

Lew has served on the program planning committee and participated as a speaker or moderator for every National Poultry Waste Management Symposium since its inception in 1988. It is with great pleasure we can dedicate this year's symposium to our friend, Dr. Lewis E. Carr.

Processing Session

Carl Johnson, Moderator
Perdue Farms, Inc.

Community Relations

Preface

The poultry and livestock industries are currently in an era of high profile issues management. Concerns of our society include the safety of food, the welfare of animals, and protection of the environment. These challenges can put the poultry industry and farmers at odds with consumers and other vocal fractions of society. Since 1988, eight National Symposia on Poultry Waste Management have addressed the latest technologies and information regarding poultry waste management.

Although there has been significant progress in the management of nutrients and by-products of the poultry industry, the public is largely unaware of the efforts, expenditures and progress poultry personnel have made as environmental stewards of our resources and environment. We must communicate the good news, success stories and progress one on one with our neighbors, in public forums and with articles, letters to the editor and by other means. Our efforts will continue in researching new solutions, implementing better technologies and sharing ideas at educational events like this symposium. However, we must not only inform others; we must follow through and be good neighbors and good stewards of our resources and animals. Furthermore, we must not only speak out among ourselves, but tell others about our successes and failures.

This educational event has always focused information at mid-level managers, and decision-makers in the poultry production and processing system. We encourage the participation of growers and independent producers as they gather new information and consider progressive technologies. The mission of the Program Committee is to provide these individuals with cutting edge, timely information to fulfill their individual and collective environmental goals.

The Program Committee wishes to thank all persons, exhibitors, corporate and government sponsors that graciously helped to make this Symposium successful and well attended.

Editorial

The manuscripts presented herein were reviewed and subjected to minor revisions to meet format requirements established by the editors. A peer review process was not used to evaluate the manuscripts. We wish to thank those authors who diligently prepared their manuscripts in a timely fashion to allow their information to be disseminated as part of the Proceedings distributed at the Symposium. Unless otherwise stated, the mention of trade names in these Proceedings does not imply endorsement by the editors or symposium sponsors.

Joseph B. Hess
Kevin D. Roberson
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OVERVIEW OF THE NPWMS PROGRAM

Richard Reynnells
National Program Leader, Animal Production Systems
U.S. Department of Agriculture, Cooperative State Research, Education and Extension Service
800 9th Street, SW, Room 3130 Waterfront Centre
Washington, DC 20250-2220

Beginning this year, leadership and coordination of the National Poultry Waste Management Symposium (NPWMS) has been transferred to university faculty. The future success of these workshops will depend upon a firm commitment by faculty and industry personnel to continue this national effort that was initiated by and for the poultry system (university, industry, allied industry, government). Unfortunately, these personnel are already overloaded to the saturation point.

The history of the NPWMS is available in the 2002 proceedings as part of the Introduction. We must now deal with the future of this meeting. How can we build on the tradition of cooperation and a common vision, to follow through on the stated preference of many in the poultry system to continue what has been a very informative and beneficial symposium series? It is critical the desire to continue the NPWMS is a personal commitment to this important national environmental education program. It will take a special effort to continue the series, given: the present situation of a reduced number of personnel in the Land Grant Universities; the assignment of additional general responsibilities to existing poultry system personnel; the need to address additional environmental protection regulations that incorporate air quality considerations; and changes to existing water quality regulations.

Everyone must consider their level of commitment to providing this national environmental program for poultry. The organizing committee must be inclusive and contain dedicated leaders for each section, so tasks are completed in a timely manner and assistance is provided while there is time to compensate for problems. It is not enough for a few people to make this a priority and lead the committee. Rather, each committee member must communicate and help others compensate for our many time constraints and local responsibilities. The success of the program from 1988 to this point has been due to the cooperation of a large number of persons, each taking a small portion of the job and following through on their commitment. These comments are to ensure previous cooperative efforts are recognized, and there is a better appreciation of the probable numerous competing demands on time in the future, so everyone may realistically consider the situation and the consequences of their actions or inaction.

When it is time for the workshop to be discontinued, then make that decision. Do not let it die of neglect. If it is terminated, then any residual funds will go to the Poultry Science Association for an environmental award to be made available in perpetuity.

Mike Hulet led the effort as Coordinator in 2004, and Susan Watkins will lead in 2006. We now need to identify a leader for 2008. These coordinators need a reliable and enthusiastic team to create this important meeting.

Due to bio-security concerns, we did not have the traditional tour of industry production or processing sites. A suggestion has been made to create a virtual tour for the third day. This will take a lot of work and the process should start soon after this meeting. As always, the organizing committee welcomes volunteers for this or other special sessions, and program or special committees such as Publicity, Sponsorship, Poster, or Exhibits.

result of intensive animal production and the related concentration of odors, dust, and other air contaminants. In addition, there is the potential for flies and other pests bothering neighbors. Part of the problem is the philosophical prejudice by many in rural and urban society against large, vertically integrated, and intensive farming operations. Speakers will discuss the legal and regulatory implications of air and water contamination.

Educational programs that help farmers fulfill their environmental stewardship responsibilities are the focus of several presentations. Speakers in the Processing Section also will underscore the importance of society's acceptance of agriculture as good neighbors. They will discuss bacterial contamination of the environment near agricultural facilities, and the impact of anti-microbials on waste water. New procedures and technologies that minimize pollution or water use, and turn waste into value added resources are important components of this section.

The Production Section also emphasizes the air quality aspects of poultry production and how these pollutants impact rural society. CAFO compliance and CNMP's comprise the afternoon schedule.

We hope you find the workshop productive and enjoyable. Please remember to fill out the evaluation and turn it in at the meeting or mail it according to the instructions. The organizing committee needs that information to improve the program each year.

LEGAL IMPLICATIONS OF THE CLEAN WATER ACT

Janie Hipp
Assistant Professor and Natural Resources Regulatory Policy Specialist
University of Arkansas
217AA AEAB
Fayetteville, AR 72701

Ph: 479-575-6935; Fax: 479-575-5306
jhipp@uark.edu

No Paper Submitted

AIR QUALITY: WHAT REGULATIONS WILL BE APPLIED TO THE POULTRY INDUSTRY IN THE FUTURE?

Anthony J. Pescatore
Department of Animal Sciences
University of Kentucky
604 Garrigus Building
Lexington, KY 40546-0215

Ph. 859-257-7529; Fax: 859-323-1027
Apescato@uky.edu

Air emissions are an emerging issue for all of animal agriculture. How existing regulations are applied to animal agriculture facilities in the future is a topic of great debate. This debate is taking place at the national level, at the state level and more importantly in the judicial system. The questions that are being debated are: what regulations apply to agriculture; what emissions will be regulated; what level of emissions; how emissions rates will be determined and by what method; who is responsible and what facilities will be regulated and what corrective action if any will be necessary for compliance. How existing and new regulations are applied to animal agriculture will impact the profitability and sustainability of the U.S. Poultry Industry. Production facilities of all animal agriculture may be faced with adopting new technologies or new management procedures. Poultry producers need to be aware of the issues and the future impact that these issues can have on their operations.

The issue of air emissions needs to be discussed as two aspects, one being the regulatory and the other as a nuisance legal action. Under regulatory there are three specific statues that are the center of this debate: the Clean Air Act (CAA); the Comprehensive Environment Response, Compensation and Liability Act (CERCLA) and the Emergency Planning and Community Right to Know Act (EPCRA). Understanding these statues and their potential application to agriculture facilities is essential for the poultry industry to actively participate in the debate.

Clean Air Act (CAA)

The CAA is the federal statute that gives the government the authority to regulate the amount of pollutants that can be released into the air. The CAA covers both stationary and mobile sources of pollutants. The regulatory agency of this act is the Federal Environmental Protection Agency (EPA) and is responsible for regulations and enforcement. Under this law EPA is required to set National Ambient Air Quality Standards for pollutants that are considered harmful to public health and the environment. Six principal pollutants are considered criteria pollutants that can impact public health and public welfare. These six criteria pollutants are carbon monoxide, lead, nitrogen dioxide, ozone, sulfur oxides and particulate matter (PM_{10} and $PM_{2.5}$). The National Ambient Air Quality Standards for the criteria pollutants are listed in the table below.

environment. The key point is that the surrounding community must be notified in order to respond and protect the health and welfare of the community. As in the case of CERCLA, EPCRA includes hydrogen sulfide and ammonia as reportable compounds. The reportable level of ammonia under both EPCRA and CERCLA is 100 lbs/day from a facility. The question that is being debated over EPCRA is whether the normal operation of an agricultural facility is an intended action situation or not.

Under both CERCLA and EPCRA there are provisions for lawsuits against operations. Environmental activist groups and private citizens have brought lawsuits against swine and poultry operations in two states. These lawsuits will determine if these regulations apply to animal operation and delineate the liability issue.

Public Nuisance

The issue of public nuisance laws and lawsuits are a growing concern for animal agriculture. While many states have right to farm laws, they do not always prevent legal action on animal operations. Even if producers successfully defend their operations there are substantial legal costs and personal stress. In order for producers to protect themselves, they must implement best management practices and be good environmental stewards. Two recent cases illustrate the effect that the court system can have on an animal operation. In a case in the Midwest, a large layer operation was forced by court order to depopulate hens due to a nuisance lawsuit based on odor and fly problems. In a southern state a local public attorney brought criminal public nuisance charges against a poultry operation and a poultry integrator. The charges were based on odor complaints. The court found that there was one day that a public nuisance occurred and found the defendants guilty and issued a small fine. The threat of future charges forced the poultry producer to close the operation. Nuisance complaints and lawsuits will be a constant source of concern for all of animal agriculture.

Summary

Air emissions will be one of the greatest challenges facing the poultry industry in the future. Federal regulations as they are applied to animal agriculture will be an area that will be further defined as additional baseline data is obtained. Public and private lawsuits will be increasingly filed against animal operations. Poultry producers need to adopt best management practices for their operations.

LOUISIANA MASTER FARMER PROGRAM

Carrie Castille Mendoza
Louisiana Master Farmer Program Coordinator
P. O. Box 25100
Louisiana State University
Baton Rouge, LA 70894-5100

Ph: 225-578-2906; Fax: 225-578-4225
CMendoza@agcenter.lsu.edu; http://www.lsuagcenter.com/masterfarmer

Introduction

Public concern over the effects of agriculture and forestry production practices on environmental quality has grown in recent years. Based on current data, Louisiana has 285 water bodies listed as being impaired (not meeting established standards for oxygen, fecal material, metals, etc) for one or more reasons. Only 91 of our 476 designated water bodies are currently considered fully meeting standards. These environmental concerns have lead to the multi-agency effort to develop the *Master Farmer Program*. The *Master Farmer Program* is an effort to demonstrate that agricultural producers can, and will voluntarily reduce the impact that agricultural production has on Louisiana's environment.

Research and educational programs on environmental issues has always been an important part of the LSU AgCenter's mission. The LSU AgCenter has taken the lead in developing the *Master Farmer Program* in an effort to help agricultural producers address environmental stewardship through voluntary, effective and economically achievable BMPs.

In an effort to address agriculture's contribution to water quality impairments, the LSU AgCenter, USDA-Natural Resources Conservation Service (NRCS), Louisiana Farm Bureau Federation (LFBF), Louisiana Department of Environmental Quality (LDEQ), Louisiana Department of Natural Resources (LDNR), Louisiana Soil & Water Conservation Districts (LACD), Louisiana Cattlemen's Association (LCA) and the Louisiana Department of Agriculture and Forestry (LDAF), Louisiana Rice Growers Association, American Sugar Cane League, Louisiana Soybean Association, and the National Oceanic and Atmospheric Administration (NOAA) are in the process of developing a Master Farmer Program for Louisiana.

Components of the Master Farmer Program

Due to the increased pressure for regulatory control of production agriculture, the initial focus of the program will be the Environmental Stewardship component. The Environmental Stewardship component will have three Phases. Phase I will focus on environmental issues specific to production agriculture and commodity specific BMPs and their implementation.

Specific topics addressed in Environmental Stewardship – Phase I include:

- National water quality standards and the Clean Water Act (CWA)
- Louisiana water quality standards
- Total Maximum Daily Loads (TMDLs)

The Master Poultry Grower program has already begun in north Louisiana, and we are seeing great progress in this program.

Summary

Louisiana leads the nation in environmental stewardship with the implementation of the Master Farmer Program. In this effort to promote environmental stewardship, the program environmental stewardship, the program is partnering with Mississippi and Arkansas to develop a multi-state Master Farmer Program.

A Master Farmer Program website has been developed to provide you with information about the program, registration form, scheduled meetings, and related topics. This site can be found at: *www.lsuagcenter.com/masterfarmer*. For additional information about the Master Farmer Program please contact Carrie Castille, LSU AgCenter at (225) 578-2906.

GEORGIA POULTRY EMS PILOT PROJECT

Casey W. Ritz
Department of Poultry Science
L. Mark Risse and Thomas M. Bass
Department of Bio and Ag Engineering
The University of Georgia
Athens, Georgia 30602

Ph: 706/624-1402; Fax: 706/624-1404
critz@uga.edu; http://department.caes.uga.edu/poultry/

Georgia's poultry industry represents the strongest commodity in the state, with approximately 1.3 billion broilers produced annually. Nutrient management planning has been a major focus of education and technical assistance in the state of Georgia for several years. Through the efforts of the University of Georgia College of Agricultural and Environmental Sciences and poultry industry leaders, all growers have been through basic nutrient management planning and land application training. Urban encroachment, regulatory changes and environmental awareness have necessitated many changes in the industry. In general, the need for farmers to document their practices and stewardship efforts is higher than ever. As part of a national project to evaluate the use of environmental management systems (EMS) on livestock operations, Georgia was selected as the lead state to pilot test a poultry-specific EMS. Pennsylvania and Virginia were two other poultry pilot test states with the national project.

Project staff: Dr. Mark Risse and Mr. Thomas Bass, UGA Bio and Ag Engineering, Dr. Casey Ritz, UGA Poultry Science, and Ms. Carrie-Lynn Presley Fowler, graduate student, UGA Ag Economics. Dr. Risse is a Co-PI and poultry commodity lead on the National EMS Project Team and project head for Georgia.

Project Objectives: To qualitatively assess:

1. The role of **state policy incentives or sanctions** in farmer commitment to environmental management systems.
2. The role of **educational or coaching strategy** in farmer commitment to environmental management systems.
3. The role of **training and support materials** in farmer commitment to environmental management systems.
4. The role of **farmer background, attitudes and characteristics in farmer commitment** to environmental management systems.
5. The **relevance and usefulness** of the environmental management systems framework for farmers **under differing circumstances.**
6. The **practical impacts of the pilot farmers' environmental management systems in terms of their attitudes, commitment** to the process of continuous environmental improvement, and changes in livestock, manure and other farm management practices.

The project team spent the most time with the Extension-led group. Growers attended 4 group meetings and completed activities on their own between these meetings. At each meeting, a topic or exercise was introduced and initiated. Reviews of previous work were conducted at subsequent meetings before moving to the next step. From these meetings and interaction with the growers, it was readily apparent that the producers preferred a gradual step-by-step approach. The concept of an EMS was difficult to grasp. However, they could see the benefits of the various components. Another stumbling block was that producers felt that some of the paper work and record keeping was duplicative of other existing efforts such as nutrient management planning. Our guidebook was modified to try and better explain how the EMS ties these documents together rather than duplicating them.

The self-led group attended one group meeting and subsequently received instructions and tools via mail. Phone updates were also made. These producers were encouraged to seek assistance from a variety of resources and agencies in order to complete their EMSs. They also had access to the project team for questions and assistance upon request, although the majority worked independently and did not attend ongoing group meetings as provided to the Extension-led group.

In addition to testing three methods of EMS development, Georgia was also unique in the fact that it offered several options for completing the assessment component of the project. Producers were made aware of the following options: Extension specialist review, Environmental Management Solution's On Farm Assessment and Environmental Review Program, State and National Farm*A*Syst assessments, the Georgia Poultry Self Assessment Guide developed as part of this project, NRCS conservation planning resources, and farm family/employee brainstorming. Extension specialist-conducted and Farm*A*Syst assessments were the most popular assessment tool choices. Two farmers had the EMS-OFAER review. Few participating producers chose to use the independent self assessment tool developed for this project, although both consultants indicated that they used these tools in their EMS development process with farmers. From this point of view, it may be appropriate to target these assessment materials toward the coaches and assistance providers rather than the producers.

Two consulting firms each worked with a farm to develop an EMS. After one orientation meeting, these growers worked solely with their respective consultant to complete the project. The consultants were Agri-Waste Technology Incorporated and Environmental Management Services, both of North Carolina. One of these consultants had significant experience with industrial EMS development but little agricultural background while the other had significant agricultural experience in nutrient management planning and livestock waste but had never developed an EMS. Each consultant provided completed EMSs to the project team for review along with reports. Both consultants developed good materials and provided the farmers with useful assistance. The completed EMSs were high quality and the producers indicated that they were pleased with the assistance provided. EMS costs for these consultants ranged from $4,000 to $16,000 although both consultants indicated that these costs would be considerably less if multiple EMSs were being developed simultaneously.

Findings, Lessons learned

Materials: Producers indicated that the draft materials were often cumbersome and difficult to follow and that it was difficult for them to understand how these exercises would help them. The independent study or self-led group relied heavily on these materials and their lack of success is largely attributed to this problem. The final draft of the guidebook and new assessment modules were structured to allow the materials to function more independently and to better explain how these tools work with existing farm procedures.

result of his farming and environmental practices. The plan could serve as documentation for his case. He also indicated that a guidebook for an EMS had to be poultry-specific and current in order to be of any use to growers.

Summary

Through the implementation and pilot testing of a poultry-specific EMS, we learned that it will be difficult to implement EMSs on a widespread basis in Georgia unless mandated by state or federal regulation. Improved tools, better incentives, and one-on-one technical assistance will be required to encourage producer participation. If these barriers can be overcome, environmental benefits and improved management may be realized through EMS adoption. Further efforts should focus on building capacity to supply producer assistance and working with cutting edge producers that are more likely to voluntarily adopt EMS principles.

ENVIRONMENTAL CERTIFICATION—THE PEACCE PROGRAM

Robert Meinen
Department of Dairy & Animal Science
The Pennsylvania State University
303 Agricultural Science & Industries Building
University Park, PA 16802

Phone: (814) 865-2987
Fax: (814) 865-7442
rjm134@psu.edu

Introduction

The Pennsylvania Environmental Agricultural Conservation Certification of Excellence (PEACCE) program promotes agricultural practices that enhance environmental stewardship and recognize livestock and poultry producers who meet environmental criteria established by the PEACCE committee. The criteria assure the farm operation is compliant with environmental law and maintaining a positive community image.

PEACCE is a cooperative effort of several organizations in Pennsylvania including:

1. The Pennsylvania State University (PSU)
2. Pennsylvania Association of Conservation Districts (PACD)
3. Pennsylvania Environmental Council (PEC)
4. Pennsylvania State Conservation Commission
5. PennAg Industries Association
6. Pennsylvania Department of Agriculture
7. Pennsylvania Farm Bureau
8. Pennsylvania Agricultural Ombudsman Program
9. USDA Natural Resources Conservation Service (PA)
10. Pennsylvania Department of Environmental Protection

PSU, PACD and PEC serve as voting members on a board of directors, and collectively have authority to approve or revoke certification status. The other entities listed serve in advisory capacities.

Certification Process

The certification process consists of three steps; completion of an Environmental Awareness Course, participation in a third-party on-farm environmental review and a verification checklist completed by the county conservation district.

The Environmental Awareness Course was developed as a result of a state senate resolution passed in 1997. The course curriculum addresses basic best management practices for several areas including community image, nutrient utilization, manure utilization and farm odors. PEACCE criteria require that participants demonstrate their knowledge of environmental issue and public concerns that affect and lots. Plans may provide an implementation schedule for best management practices; these practices must be implemented on schedule for a farm to be PEACCE certified.

4. Pesticide Application – Use of pesticides must be conducted under an application license and pesticides must be stored in accordance with the law.
5. General Farm Appearance – The PEACCE committee finds it imperative that certified farms present a good appearance to their community.
6. OFAER Assessment – The producer is asked to volunteer the confidential OFAER report to the evaluators. The conservation district can then review the reports challenges and recommendations with the producer. To become PEACCE certified all high risk areas listed on the report must have been addressed. It is then verified that the producer is making good faith efforts to improve areas listed in non-high risk challenges.

Upon successful completion of the county checklist form the conservation district submits the form to the PEACCE committee for review and approval. Once approved the farm and its management is recognized as PEACCE certified and receives a two-sided metal sign for public display at the farm gate or on a building. Each side of the sign contains the PEACCE logo and the words "Environmental Excellence".

PEACCE farms must maintain certification by demonstrating continued compliance on an annual basis. New OFAER visits are made if the farm has significant changes in livestock, manure handling or crop management.

Discussion

PEACCE was piloted in 2002 in the counties of Berks, Chester and Lancaster. In 2003 the pilot was expanded. During the pilot phase thirty-three farms received certification. Table 1 reflects the counties where farms were certified during the pilot phase as well as the number of farms certified in each county. The type and number of livestock on certified farms has varied greatly; from a farm with sixteen cows with calves and sixteen ewes with lambs to large dairies to a poultry farm with a flock of 1,000,000 birds.

Table 1: Counties where PEACCE pilot was conducted and number of farms certified in each county.

County	Number of farms certified during pilot
Adams	1
Berks	8
Bradford	1
Centre	1
Chester	1
Lancaster	9
Lawrence	1
Lebanon	1
Northumberland	1
Schuylkill	1
Snyder	1

PUBLIC PERCEPTIONS OF WASTE MANAGEMENT ISSUES:
When city folk live next door and chickens no longer smell like money

Wes Jamison
Associate Professor of Agriculture
& Director of the Agricultural Stewardship Center
Dordt College
498 4th Avenue NE
Sioux Center, IA 51250

Ph: 712-722-6271; Fax: 712-722-6336
wjamison@dordt.edu

Introduction

Poultry producers have traditionally accepted that chicken production brings associated environmental consequences, including waste management issues and aesthetic concerns like smells and pests. However, until relatively recently, poultry production occurred in rural environments typified by low population density, and the surrounding neighbors understood and tacitly accepted the aforementioned consequences. Indeed, an axiomatic response of poultry producers to infrequent inquires about smells traditionally followed the "that's the smell of money" rationale. Implicitly, that response reflected the consensus among producers and neighbors that poultry production brought certain unpleasant consequences along with the benefits, and that those benefits were wide spread, tangible, and clearly outweighed any detriments. That consensus is rapidly disintegrating in many regions, and in some areas it no longer exists.

Largely because of urban encroachment into rural areas, agricultural production in general and poultry production in particular can no longer claim isolation as a buttress against urban opinions. Likewise, and far more important, a new phenomenon threatens whatever consensus remains for accepting the offensive byproducts of intensive animal production. Increasingly affluent "Rurbanites"---defined as urbanites that have the resources to construct a tailored rural lifestyle---now seek residence in rural settings, seeking the lifestyle benefits of living in low population density areas that historically have been characterized by measures of social cohesion and accountability like low crime, low stress, low traffic, e.g. "a place where everybody knows your name." Nonetheless, these rurbanites bring with them their urban definitions of place, and their view of the country life is radically different than their poultry producing neighbors. In short, one man's smell of money is another's offensive offal. This encroachment of urban sensitivities into poultry producing regions, and its ability to demand and receive changes in waste management practices, cannot be underestimated.

Epistemological Conflict

Agrarianism, or the view that there is something unique, virtuous and valuable about country life and farm environments, is nothing new. Originating before the American Revolution, the country life has always had an allure as a place that offered a respite from the evils of the City, a place that in the 1920's Liberty Hyde Bailey called "a parasite, fanning out its roots into the open country and draining it of its subsistence." In contrast, the country, and farming in particular, has always been seen as a place of freedom and independence, a place where honest people engaged in work that was marked by self-

Future Trends

As population centers move increasingly into traditional poultry producing regions, these conflicts will amplify and increase. Carrying with them a "rurban" worldview---defined as the filtering of reality through the aesthetics of urban and suburban life coupled to a desire to escape its consequences through the construction of individually tailored "rurban" lifestyles---the new rural residents will not willingly accommodate agricultural production that offends their sensibilities. By definition, rurbanites are socio-demographic elites who have the time, money, and sophistication to engage in politics and influence agricultural policy. They have the motive, e.g. maintenance of their ideal, and the opportunity to engage in discussions involving waste management issues, and they will do so. And ultimately, the numbers are on the side of the rurbanites: representative government and incrementalism can forestall change for a time, but democratic forces inevitably will be expressed in increasing pressure on the poultry industry to either use expensive waste treatment facilities, or move somewhere else. More important, romantic agrarianism, with its ideal of the small diversified family farm that is devoid of environmental consequence or aesthetic offense, carries tremendous sway among the urban majorities in poultry producing states. People filter facts through their expectations and myths, and whether those myths are grounded in fact, are obtainable, or even desirable, is beside the point: urban populations that are proximate to poultry farms will decreasingly support industrial animal agriculture because it neither coincides with their ideal of country life, nor with their aesthetic sensibilities when they finally encounter it. Ultimately, if present population and demographic shifts continue, the poultry industry will be forced to change or move.

TMDL AND NUTRIENT TRADING: HOW WILL IT WORK?

H. L. Goodwin, Jr.
Associate Professor and Poultry Economist
Department of Agricultural Economics and Agribusiness
University of Arkansas
217 Agriculture Building
Fayetteville, AR 72701
Ph: 479-575-2283; Fax: 479-575-5306
haroldg@uark.edu

No Paper Submitted

PRODUCTION OF ACTIVATED CARBONS FROM POULTRY LITTER

Isabel M. Lima
United States Department of Agriculture
Agriculture Research Service
Southern Regional Research Center
1100 Robert E. Lee Blvd
New Orleans, LA 70179

Ph: 504-286-4515, Fax: 504-286-4419
imlima@srrc.ars.usda.gov; http://msa.ars.usda.gov/la/srrc/index.htm

Disposal of animal manure is one of the biggest problems facing agriculture today. There are 8.6 billion broilers and almost 300 million turkeys produced in the United States each year for human consumption (NASS, 2004) creating over 10 million tons of manure. These birds are confined in concentrated animal feeding operations, CAFO's, which usually result in excessive localized land application of this manure due to over production. Currently, animal manure is valued at between \$3 and \$10 per ton and most of it is converted into fertilizer. Unfortunately, when added to soil, a buildup of nutrients, namely nitrogen and phosphorus can occur, especially if it is applied repeatedly to the same area. This substantial quantity of manure may pose a threat to public health and the environment because of potential contamination of air, ground and surface water sources via run-off and odor releases. The EPA Quality Assessments Report to Congress in 2000 reported that out of 3.7 million miles of streams and rivers in the U.S., farming might impair water quality to some degree in 18% of the 0.7 million miles that states and tribes assessed during 2000. When specifying the type of agricultural activity, animal feeding operations were reported to degrade up to 25,000 river and stream miles (2000 EPA Water Quality Assessments Report to Congress).

Current approaches for poultry manure disposal such as land application as fertilizer, as well as other manure uses, such as burning for fuel recovery or land filling, produce low-value alternatives. In contrast to low value land application, the development of value-added granular activated carbon, GAC, from poultry manure could be a potentially profitable endeavor and at the same time reduce public health and environmental risks. Our research group with the Commodity Utilization Research Unit at ARS' Southern Regional Research Center in New Orleans, Louisiana, is looking into converting poultry manure into a material that can be used to help keep the environment clean. Our research project, unique to ARS and to our best knowledge, with unprecedented art, involves manufacturing activated carbons from animal waste, with a strong focus on poultry manure.

Converting poultry manure into activated carbons is a much less detrimental solution to utilize animal waste. GAC are high porosity, high surface area materials used in industry for purification and chemical recovery operations as well as environmental remediation. They are utilized to soak up unwanted pollutants. With the availability of safe drinking water becoming a serious concern in the future and the consequent increase in regulations from EPA further limiting the levels of metal contaminants released from waste water facilities, the need for activated carbons will continue to rise. Present demand for activated carbon is about 420 million lbs in the United States with demand growing at 3% per year. Bituminous coal and coconut shells are two common materials used to manufacture activated carbons. However, coal is an expensive and nonrenewable resource, costing between \$60 and \$80 per ton, while coconut shells are not readily available.

There is a growing interest in water remediation, particularly for metals.. However, commercial carbons, while excellent at adsorbing various organic constituents from air or water, have limited ability to remove metals. The production of GACs from poultry waste can serve two important purposes: utilize large

Broiler litter and broiler cake samples were obtained from the USDA-ARS, Poultry Research Unit (Starkville, MS). Turkey litter and turkey cake samples were obtained from Boeckmann Farms, in California, MO. Samples were milled (<1 mm) and subsequently pelletized in a pellet mill equipped with a 3/16 in die plate. Pelletized manure was pyrolyzed and steam activated. Steam activation involved injecting water at different flow rates (1, 3 or 5 ml/min) using a peristaltic pump, into a nitrogen gas flow entering the retort at 800°C for periods varying from 15 to 75 min. Once cooled, samples were acid washed, water rinsed, dried and sieved. Samples were analyzed for yield, ash removed during acid washing, surface and micropore area, bulk density and attrition (Table 1); and metal ion adsorption (individual and competition mode) (Figure 1). Four metal ions were chosen for the study: Cu^{2+}, Cd^{2+}, Ni^{2+} and Zn^{2+}. All single and multiple metal ion solutions were made to a concentration of 5 mM metal ion in a 0.07 M sodium acetate – 0.03 M acetic acid buffer, pH 4.8. The multiple metal ion solutions contained all four metal ions ($CuCl_2$, $Zn(NO_3)_2$, $Ni(NO_3)_2$ and $Cd(NO_3)_2$), each at 5 mM. For equilibrium measurements, a solution containing 0.25 g of carbon (18x40 mesh) and 25 ml of the metal solution was stirred for 24 hr at 250 rpm. A filtered aliquot of the suspension was drawn off, diluted to 1:10 by volume with 4 vol% HNO_3 and analyzed by inductively coupled plasma, ICP spectroscopy.

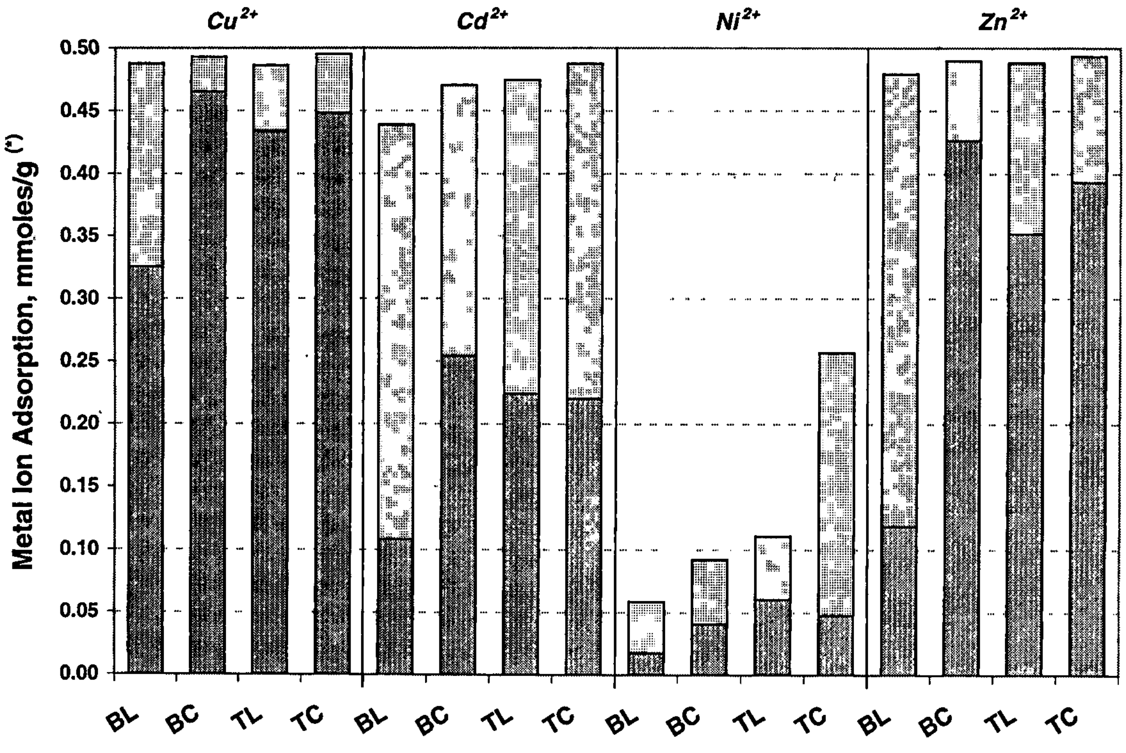

Figure 1: Comparison between adsorption efficiencies of metal ions in solution in both individual and competitive mode, by broiler litter (BL), broiler cake (BC) and turkey litter (TL) and turkey cake (TC) – based carbons.

(*) Total available copper ion for adsorption was 0.52 millimole per gram of carbon.

COMMERCIALIZATION OF THE THERMAL CONVERSION PROCESS: AGRICULTURAL RESIDUES INTO RENEWABLE FUELS

Paul S. Halberstadt
V.P. Technical Services
Renewable Environmental Solutions, LLC
2001 Butterfield Road
Downers Grove, IL 60515

Ph: 630 512 1190
e-mail: paul.halberstadt@conagrafoods.com

Renewable Environmental Solutions (RES) in Carthage, MO has begun operation of Changing World Technology's patented Thermal Conversion Process (TCP) to convert poultry offal into renewable fuels. The process uses water, temperature and pressure to hydrolyze agricultural residues for conversion into renewable products. The TCP is similar to the natural processes in the Earth's crust where oils and natural gases are created. The TCP can utilize low value agricultural materials that are not part of the human food supply and produce renewable fuels. The TCP can utilize a wide range of agricultural residuals in their natural conditions because the process utilizes the moisture contained in the feedstock residuals as the process water for hydrolysis. The renewable fuels produced by the TCP are oils, fatty acids, fuels gas, carbon and fertilizers.

The RES Carthage facility's feedstock is poultry offal, including feathers, meat, bones and blood, residual greases from food processing plants, restaurant greases, and wastewater treatment primary sludges. The raw material is transferred to the plant by dump trailers and tanker trucks. Approximately, 200 to 250 tons per day are received and processed by the facility. The poultry offal is combined in a receiving bin and the liquids are pumped to process storage tanks for use in the blending and grinding steps of raw material processing.

The TCP processing steps are: 1) Material receiving, 2) Metal detection, 3) Grinding and blending feedstock into a mixed slurry, 4) Process slurry storage, 5) Pre-conditioning and heating, 6) First stage reaction at 250 to 350 C for 30 minutes to 2 hours, 7) Separation of converted solids and liquids, 8) Separation of converted liquids, 9) Second stage reaction at 500 to 600 C, 10) Recovery of produced water, 11) Converted intermediate product processing into final products, 12) Final products storage, and 13) Utilities.

The produced products are oils (-API 25 to 40), fatty acids (-C16 & C18), produced gas (-850 to 900 BTU/scf), solid fertilizer (-11% P & 13% Ca), liquid fertilizer, and produced water. A 200 to 250 ton/day TCP plant with 60 to 50% moisture will produce daily approximately 200 barrels of oil, 150 barrels of fatty acids, 275 MM BTU of fuel gas, 10 tons dry fertilizer, 6,000 gallons liquid fertilizer and 25,000 gallons produced water. Testing and optimization of the produced products is ongoing for the initial commercial facility in Carthage, MO. These activities are planned to continue for 2004/2005 with full production throughput capacity achieved by the end of 2004.

WHEN MUNICIPALITIES SUE THE POULTRY INDUSTRY: WHO WINS?

H. L. Goodwin, Jr.
Associate Professor and Poultry Economist
Department of Agricultural Economics and Agribusiness
University of Arkansas
217 Agriculture Building
Fayetteville, AR 72701
Ph: 479-575-2283; Fax: 479-575-5306
haroldg@uark.edu

No Paper Submitted

TORNADO-IN-A-CAN

Whit Davis
Director of Sales & Marketing
Vortex Dehydration Systems
7509 Connelley Drive, Suite E
Hanover, MD 21146

Ph: (410)553-8010; Fax: (410)553-8002
davis@vortexdehydration.com; www.vortexdehydration.com

Introduction

Vortex Dehydration Systems (VDS) is introducing the exciting revolutionary capabilities of the Windhexe technology, also known as "Tornado-in-a-Can", as a "value-added" technology. The Windhexe technology uses low-pressure air to create a vortex (or tiny tornado) to dehydrate and pulverize products to a fine dry powder...with no moving parts. The value of the Windhexe technology is that it makes "bad" products "good" and "good" products "better". The Windhexe is currently being developed and used to process Coal, Biosolids, Pulp and Paper Sludge, Trash and Food.

With regards to the Poultry Industry, the Windhexe can be used to process edible meat byproducts that are currently being disposed of in rendering. Today, the focus is on selling chicken parts to the customers...and fewer whole birds. This growth in the "cut-up" market has resulted in more and more "edible" parts not making it to the market shelves and going to rendering; including backs, skins, hearts, livers, etc. With the Atkin's Diet craze, this has only helped to fuel this activity. VDS's position is...if it is an edible product, handle it in an edible manner and process the material using edible processing methods to maximize product value.

The Windhexe is capable of processing some of these products straight without any type of preprocessing. There are, however, products that cannot be run straight through the Windhexe due to their high oil content; i.e. backs and skins. To address this issue, VDS looked at ways to preprocess the product to reduce the overall percentage of oil in the raw material. The result was the development of a "Wet Processing" System where the oil and a large percentage of moisture are squeezed out of the product mechanically. On a raw basis; chicken backs and skins are generally 30% oil. This means that from a million pounds of backs and skins, approximately 270,000 lbs of edible oil can be recovered (with a 90% recovery). The other product produced from this process is an edible chicken broth.

The benefit to the Windhexe by squeezing out a majority of the water and oil mechanically before drying is that it significantly increases the Windhexe's efficiency in drying the solids; less energy needed to remove the water. The primary benefit is that the Windhexe is an edible processing method that produces an edible product. From an environmental standpoint, this process is proven to be both environmentally friendly and neighborly.

SOURCE TRACKING OF FECAL COLIFORM BACTERIA

Peter G. Hartel
Department of Crop and Soil Sciences
3111 Plant Sciences
University of Georgia,
Athens, GA 30602-7272
Phone: (706) 542-0898; Fax: (706) 542-0914
pghartel@uga.edu

Introduction

Fecal contamination of water can cause illness. For this reason, it is important to identify sources of fecal contamination, and, when possible, reduce or eliminate them. Bacterial source tracking (BST) identifies the sources of fecal contamination to water bodies using a variety of different phenotypic, genotypic, and chemical methods. Phenotypic methods are based on traits expressed by the bacterium, like antibiotic resistance; genotypic methods are based on differences in DNA, like those associated with different ribotypes; and chemical methods are based on compounds associated primarily with human sewage, like optical brighteners in dishwashing liquids and laundry detergents. Although BST is still in its infancy and there are still a number of methodological and statistical problems to solve, what is important for poultry growers to know is that BST can identify fecal contamination of water bodies specifically from poultry wastes, whether these wastes are landspread as part of good agronomic practice or not.

Fecal Contamination of the Environment by Poultry Wastes

Before considering how BST helps poultry growers, it is important to consider the evidence that suggests poultry wastes are responsible for contaminating water bodies with fecal bacteria. Much of this evidence is based on fecal coliform data. Fecal coliforms are bacteria that normally inhabit the intestinal tracts of warm-blooded animals, including humans. Four bacterial species essentially comprise the entire group: *Escherichia coli*, *Enterobacter aerogenes*, *Klebsiella pneumoniae*, and *Citrobacter freundii*. The test for fecal coliforms is based on growth in a special medium at 44.5±0.2 °C; therefore, these bacteria are thermotolerant isolates of the species. These bacteria are not pathogens, but indicator bacteria: their presence *indicates* that bacterial pathogens may be present. For example, if numbers of fecal coliforms exceed 2,000 per 100 mL of water, then the likelihood that bacterial pathogens are in the water is 98.1% (Geldreich, 1970). For this reason, fecal coliforms are an accepted means of assessing soil and water quality (Clesceri et al., 1998).

Much of the data that suggests poultry wastes are responsible for contaminating water bodies with fecal bacteria are contradictory. On the one hand, runoff from a field amended with 5 metric tons of layer manure or broiler litter had >2,500,000 fecal coliforms per 100 mL for the layer manure-amended plots, and >3,300,000 fecal coliforms per 100 mL for the broiler litter-amended plots (Edwards and Daniel, 1994). Similar results have been observed in other studies of fecal

Targeted Sampling and BST

These changes are of small comfort to a poultry grower accused of contaminating water bodies with fecal bacteria. In this case, growers should consider BST. However, it is necessary to revisit fecal coliforms and a commonsensical recommendation before considering this option.

Over time, it has become apparent that there are certain problems with using fecal coliforms as indicator bacteria for bacterial pathogens. By definition, fecal indicator bacteria are not supposed to persist in the environment, yet *Enterobacter aerogenes* and *Klebsiella pneumoniae* appear to be normal, free-living soil inhabitants. Therefore, the U. S. Environmental Protection Agency has recommended that thermotolerant *Escherichia coli* replace fecal coliforms as indicator bacteria

(U. S. Environmental Protection Agency, 2002). Although there are questions about the minimum number of *E. coli* necessary to represent a significant pathogen hazard (most states are adopting a standard of 126 *E. coli* per 100 mL), many states have already adopted *E. coli* as the new standard. Poultry growers should insist that *E. coli* be the standard for poultry wastes.

Although BST can identify fecal contamination specifically associated with poultry wastes, BST is expensive. Therefore, we recommend *targeted sampling* of water bodies as a prelude to BST (Kuntz et al., 2003) to identify sources of fecal contamination quickly, easily, and inexpensively (Fig. 1).

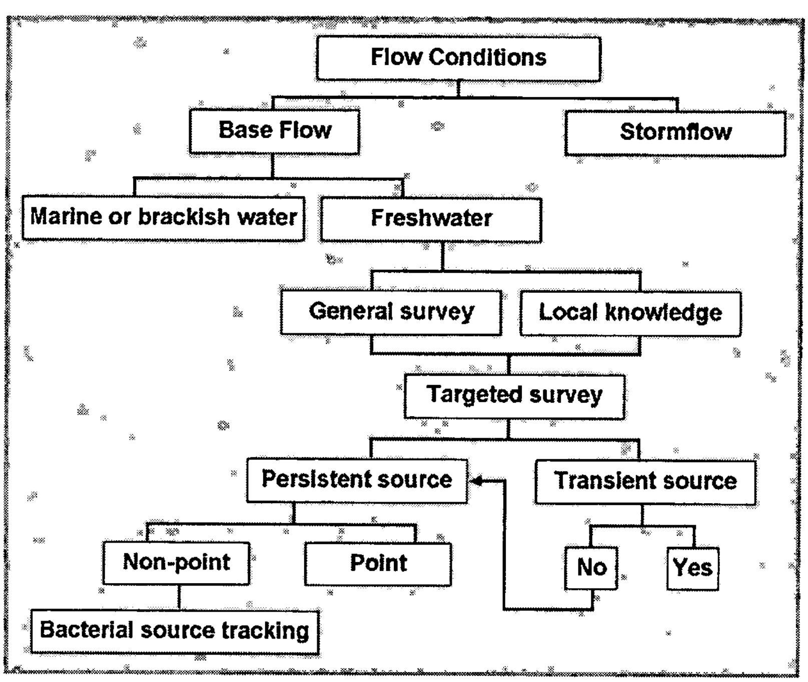

Fig. 1. Outline of targeted sampling. The outline provided under freshwater is the same for marine and brackish waters. Likewise, the scheme provided under baseflow is the same for stormflow.

Targeted sampling works much like the children's game of "hot" and "cold," and has four steps. The first step is to divide the sampling into two temporal events, one for baseflow and another for

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PROCESSING PLANTS AND WATER QUALITY: SOCIETY'S VIEWPOINT

Bill Mattos
California Poultry Federation
3117A McHenry Avenue
Modesto, CA 95350

Ph: 209-576-6355; Fax: 209-576-6119
E-mail: CalifPoultry@cs.com

Poultry industry profits are in many ways tied to the relationships that our companies have with their neighbors locally and society in general. We can ill afford to take our neighbors for granted, and in California we know that society, the environment and business can co-exist rather well when each of them understand that we are all not only working, but dedicated to protecting life around us.

In many ways, California is a catalyst for such enthusiastic relationships. We can't grow poultry or process its products without building good neighbor policies with our citizens. More than 35 million people live and work in the Golden State, and it is imperative that we do the things that these men and women expect and appreciate. After all, have you added up the amount of poultry consumed just in California? We're talking billions of pounds. We have more people living here than live in most of the Midwest combined. California's population is bigger than Canada.

When people like your company and its products they buy them. Here are some questions and comments that our companies consider frequently to be sure we are meeting the needs of society as well as our business models:

- Do we have good controls in place to protect water quality?
- We must remember that we are in business to make money, that no self-respecting reasonable business is going to break the law
- When we make our business sustainable as possible, it fits the good-business model we promote.
- The true cost of compliance is cheap when compared to the alternative (fines, lawsuits and protestors)
- Compliance is cheaper than an accident
- It's a fact that to stay in business we have to protect ourselves.
- We must evaluate the waste stream.
- We must provide for salt removal. Source reduction comes before treatment.
- We have a monetary incentive not to discharge, since whatever we discharge we have to pay for.

Finally, as animal rights and vegetarian activities are looking for anything that will assist them in denigrating our industry, we must be sure that we are meeting the needs of consumers in an ever-vigilant society. We will continue to be attacked as corporate farmers who are endangering our food supply, and anything and everything we do to enhance the viewpoints coming from society will help us as we talk about what we do to improve the quality of the world's food supply. These attacks usually come without reason and many times without any substantial proof. While it's always best to be pro-active, animal agriculture many times finds itself reacting too much. That can be resolved too by meeting society's needs.

ODOR AND AIR EMISSIONS: PROCESSING AND PLANT FACILITIES

J.A. Pierson
Georgia Tech Research Institute
Georgia Institute of Technology
575 14th Street, Atlanta, Georgia 30332-0823

Ph: 404-894-8059; Fax: 404.894.8051
john.pierson@gtri.gatech.edu; http://atrp.gatech.edu

Introduction

Nuisance odor emissions have received significant attention and research funding in recent years, however, it continues to be an area of concern at food processing and allied industry facilities. Notwithstanding recent advances in identifying specific malodorous compounds, improving control systems or approaches to cost-effectively manage emissions has been hampered by both the lack of affordable monitoring devices and cost-effective treatment technologies.

Researchers studying nuisance odors have focused on generic chemical classifications, e.g., sulfur-based mercaptans/sulfides, volatile organic aldehydes/ketones, or nitrogen-based amines/amides as a cost-effective approach for narrowing the field of suspected malodorous compounds. The tactic has produced mixed results, especially when comparing air samples from individual unit processes with emissions from air treatment technologies, e.g., scrubbers and biofilters. Even more problematic is correlating results with area sources, e.g., general emissions noted at facility boundaries.

Sources of Odors

Within processing facilities, chloramines, ozone and other advanced disinfection process emissions are sources of complaints that can stop operations. The chemistry associated with chloramination or ozonation is understood from a design standpoint, however, daily operating conditions often present sufficient variability that without real-time monitoring of emissions, periodic stoppages occur. For example, chlorine residuals standards for unfiltered chiller water provide product safety and quality, yet disinfection levels may also yield odor complaints.

Odor and/or VOC emissions from food processing wastewater operations is significant, especially from coagulant-assisted dissolved air flotation (DAF) systems treating effluents containing fat and meat residuals. It is not uncommon for water usage to range from 100,000 gallons per day at cooking operations, e.g., further processing, to over 1 million gallons per day at primary processing or rendering operations. Well over 90 percent of this water is then treated as wastewater.

EMERGING ISSUES AND TECHNOLOGIES FOR MANAGING POULTRY WASTE AND LAGOONS

F. J. Humenik, M. Rice and C. Baird
Animal Waste Management Programs
Raleigh, NC 27695
North Carolina State University
Ph: 919-515-6767; Fax: 919-513-1023
Frank_humenik@ncsu.edu

Diana Rashash
Onslow County Cooperative Extension Service
Jacksonville, North Carolina
Diana_rashash@ncsu.edu

J. Classen and S. Lear
Biological and Agricultural Engineering
North Carolina State University

Introduction

Emerging issues that will provide future direction for all waste or residuals including poultry waste are the conservation and utilization of valuable constituents including processing to value added by-products that can be marketed off farm. The high amount of phosphorous in poultry waste supports this emerging issue because it will require additional land to comply with developing regulations to apply waste at agronomic rates for phosphorous. Limitations and regulations on the operation of existing lagoons may require upgrading of existing lagoons. Lagoons that can no longer meet regulatory requirements or are not needed would have to be closed. Work is being conducted to develop, demonstrate and implement environmentally superior technologies that reduce odor and ammonia volatilization, protect environmental quality and minimize health risks. A national curriculum project addressing livestock and poultry stewardship provides information on emerging issues and technologies for managing poultry lagoons and waste.

Poultry Waste Management

The majority of poultry farms do not have lagoons. This includes the entire broiler industry and turkey industry, which both utilize litter in the house, periodically (every one-two years, generally) removed for land application as a fertilizer or other re-use. The egg industry uses three major types of manure handling systems. Roughly 50-60% on a production basis use deep stack houses, where manure drops through the cages to a lower level, from which it is periodically removed, via a front-end loader or tractor with a bucket, as a fertilizer. Although wetter than litter (typically in the 50-60% moisture range), this product is a solid and is spread by a solids spreader on fields. About 30-40% (with this amount increasing) of the egg industry utilizes belts where manure drops onto belts and is then conveyed to a separate manure storage building. This product is handled with a solids spreader when it goes to the field. This option represents the most common choice for new construction of egg facilities. Currently 10-15% of egg farms based upon industry production still use the lagoon system but its usage is rapidly decreasing. Older, smaller facilities are the most likely to have lagoons and newer, larger facilities are

Regulations have been passed in North Carolina that specify a maximum lagoon leakage of 0.003 ft/day.

These criteria directly address the major lagoon complaints of odor, discharge and leakage. However, they do not address emerging issues that will provide direction for all waste or residuals including poultry waste which are the conservation and utilization of valuable constituents including processing to value added by-products that can be marketed off farm.

Lagoon Covers

A floating cover consisting of two-parts: a permeable foam board and a proprietary biocover, was placed on a well established anaerobic swine waste lagoon 12ft deep with 3:1 side slopes and a surface area of about 0.2 ha. in August 2000. Project results are that the cover has reduced the ammonia evolution rate by approximately 80% compared to the same lagoon prior to covered installation and odor emissions were consistently very low (Miner el. al., 2003).

Record annual rainfall in 2003 and several hurricanes have not affected the cover integrity since installation in August 2000. The concentration of total nitrogen and total phosphorus continues to increase in the lagoon liquid with the level being about five pounds of plant available nitrogen per thousand gallons. This is very high for a swine waste lagoon and indicates the potential that covered swine and poultry lagoons have for conserving and harvesting valuable constituents. A project is currently underway to harvest liquid and solids from operating lagoons, lagoons to be closed and this covered lagoon.

Lagoon covers may provide a cost effective technology to greatly reduce odor and ammonia volatilization from existing lagoons. Lagoon covers can also provide for the conservation and utilization of valuable constituents in waste lagoons for processing to value added by-products that can be marketed off farm. The high amount of phosphorous in poultry waste can provide a harvested material with a much higher amount of phosphorous that may be used as an input or base product for specific recycling or utilization procedures. The harvesting of nutrients from uncovered lagoon liquids and sludges can also lower the concentrations to levels that would occur with lower loading rates and thus reduce odor and ammonia volatilization.

Lagoon Closure

Many of the about 4,500 active and 1,700 inactive swine waste lagoons and many poultry lagoons in North Carolina will have to be closed in the future because of stricter regulations and pressure to implement environmentally superior technologies. The Natural Resource Conservation Service procedure permitted in many states requires that the sludge be removed from the lagoon and land applied. In most situations this sludge cannot be applied on farm because the land application areas have received the maximum allowable nitrogen and phosphorous applications and thus it must be transported to off farm sites. Developing criteria that land application of animal and poultry waste must not exceed agronomic rates for phosphorous will have strong impacts on poultry because of the high amount of phosphorus in poultry waste and on farm areas have excess phosphorous because of having received waste for many years.

The cost of transporting the large volumes of lagoon liquid and sludge for off site management and environmental justice concerns resulting from the methods and sites used for transporting and land applying this sludge with high concentrations of potentially contaminating constituents set the basis for examining alternative technologies for a more economically and environmentally responsible technique for closing animal and poultry waste lagoons. A project is in process to evaluate the potential of a

system
Solids separation/reciprocating wetland technology system
Upflow biofiltration system
Belt system for manure removal
Belt manure removal and gasification system to thermally convert dry manure to a combustible gas stream for liquid fuel recovery
Solids separation/combustion for energy and ash recovery centralized system (this project represents three farm sites)
Solids separation/constructed wetlands system
Sequencing batch reactor (SBR) system
Manure solids conversion to insect biomass (black soldier fly larvae) for value-added processing into animal feed protein meal and oil system
ISSUES (Innovative Sustainable Systems Utilizing Economical Solutions) This project includes a mesophyllic digester, permeable lagoon cover, aerobic blanket
and micro turbine generator)
Dewatering/drying/desalinization system

The technologies now is various stages of operation and performance verification can be seen at; http://www.cals.ncsu.edu/waste_mgt/smithfield_projects/smithfieldsite.htm

Curriculum Project

A national curriculum project addressing livestock and poultry stewardship has been funded by the United States Department of Agriculture and the Environmental Protection Agency. A national team of 30 land-grant universities, USDA and EPA experts developed a user-friendly curriculum addressing environmental and regulatory compliance issues for animal agriculture. The curriculum contains information, which facilitates upgrading of existing waste management systems and implementation of environmentally superior technologies. The curriculum with 26 lessons is organized into six modules:

Introduction - Animal dietary strategies - Manure storage and treatment - Land application and nutrient management - Outdoor air quality - Related issues

Information on this curriculum can be seen at: http://lpes.org/projectbrochure.pdf.

Conclusion

Emerging issues and technologies for managing poultry waste must be to conserve and utilize valuable waste constituents including processing to value added products that can marketed off farm. This will reduce the amount of land needed for terminal management, which becomes increasingly important with developing regulations that waste can only be applied at agronomic rates for nitrogen and phosphorous because of the high amount of phosphorous in poultry waste and the land that has been used for the application of this waste over time. Lagoon covering for reduction of odor and ammonia from swine waste lagoons which result in increased concentrations of nitrogen and phosphorous in the lagoon liquid and solids show potential for upgrading poultry lagoon systems and conserving valuable nutrients. Alternative techniques for harvesting sludge from swine lagoons may be used for poultry lagoons. Educational materials being developed such as the Livestock and Poultry Environmental Stewardship Curriculum provide information on emerging issues and technologies for managing poultry and waste lagoons.

BACTERIAL POPULATIONS IN POULTRY PROCESSING PLANTS

Suresh D. Pillai
Department of Poultry Science
Kleberg Center, MS 2472
Texas A&M University
College Station, TX 77843-2472

Ph: 979-845-2994; Fax: 979-845-1921
spillai@poultry.tamu.edu

Introduction

Bacterial populations within poultry processing plant are of significant concern both from a food safety and food quality points of view. Bacterial pathogens such as *Salmonella* and *Campylobacter* which have been directly related to poultry meats are responsible for a significant number of cases of human illnesses around the world. Recent studies show that in addition to the presence of bacterial pathogens, the presence of antibiotic resistant microbial populations can also of concern to human health. The poultry processing plant should be considered as a man-made microbial ecosystem where the ultimate survival and persistence of microbial pathogens will be dictated by the activities and the environmental conditions prevailing within the plant. The types and levels of the different organisms within the processing plant will have ramifications in terms of the microbiological quality of the final poultry product in terms of food safety and spoilage as well as the quality of the waste-water effluent and aerosols generated within and around the plant. This paper will focus on the issue of bacterial pathogens and antibiotic resistance-encoding genetic sequences within poultry processing plants.

Bacterial Pathogens and Processing Plant Operations

Wilkins et al (2003) have reported the feed withdrawal longer than 10 days was associated with "dirtier" birds arriving at poultry processing plants. Out of approximately 70,000 birds that were monitored in three processing plants, greater than 70% of the birds had soiled plumage suggesting that they were very likely to contaminate the plant and equipment with microbial populations. In addition to pathogen-infected birds, the birds can also get contaminated during transportation to processing platns via contaminated ransport crates (Corry et al., 2002). The crates are either not cleaned or disinfected or that disinfection regimes are below the effective levels. Campylobacter, Salmonella, Listeria and Clostridium perfringens are key bacterial pathogens that have been isolated from processing plants (Keener et al., 2004; Logue et al., 2003a, 2003b; Craven, 2001).

From a microbiological stand point, the processing plant employs a number of procedures that can increase the shedding and spread of microbial pathogens from the carcass to other carcasses and into the environment. Procedures such as scalding, de-feathering, evisceration, carcass washings, and carcass chilling have been shown to release pathogens into the immediate surroundings. Scalding which is used to open the feather follicles to facilitate the removal of feathers and picking have been shown to enhance bacterial cross contamination and Campylobacter have been isolated from scald water (Bailey et al., 1987 ; Stern et al., 2001). Studies have, however, shown that there is no reduction in microbial loads on carcasses after the scalding and de-feathering processes implying that these processes may actual enhance microbial cross contamination rather than reducing microbial loads on carcasses (Cason et al., 1999). The de-feathering process which utilizes rubber fingers to remove the feathers is known to spread bacterial pathogens from one carcass to another (Wempe et al., 1983). Berrang and Dickens (2000) have reported their microflora. The class 2 integron variable region sequences were present in 12.5% (12/96) of the processing samples. Thirteen percent (3/24) of the post-feather removal carcasses contained the class 2 integrons while 8% (2/24) of the pre-chiller immersion and post-chiller immersion carcasses tested positive for the class 2 integron. Two separate commercial chiller tanks were also sampled daily over a 5-day period with 39 total samples analyzed. Tank A showed the highest prevalence of class 1 integrons with 47% (9/19) of samples taken showing the amplicons. Within Tank B, only 2 samples tested positive for the class 1 integron indicating a prevalence rate of 10% (2/20). Out of the 39 chiller tank samples, 31% (12/39) of the samples contained the class 1 integron gene sequence. A statistically significant ($P < 0.05$) proportion of the class 1 integrons were found in samples containing less than 18 ppm. The box and whisker plot demonstrated a predictable correlation between free chlorine level and class 1 integron presence. The commercial chiller Tank A showed high numbers of heterotrophic bacteria ranging between 10^3 CFU/ml and 10 CFU/ml. In contrast, Tank B did not show the presence of heterotrophic bacteria in any of the samples tested. There was a statistically significant correlation ($P < 0.05$) between free chlorine level present in the sample and the reduced numbers of heterotrophic bacteria. Overall, these findings identify that class 1 and class 2 integron gene sequences are capable of persisting throughout the poultry processing environment. These integron sequences are capable of persisting even within the chiller tank which has been specifically designed to reduce microbial loads and prevent cross contamination.

Bacterial Populations in Untreated Poultry Processing Waste Water

There are a number of published studies and a wealth of information regarding the chemical characteristics of poultry processing wastewater (Chen et al., 1976; Woodard et al., 1977, Newman, 1992). However, published reports on the microbiological characteristics of poultry processing wastes are limited (Menon, 1985; Pancorbo and Barnhart, 1992, Havelaar et al., 1984). The scarcity of microbiological data can be attributed to the regulations governing the disposal of processing wastewater which deal primarily with only pH, BOD, TSS and oil and grease levels.

Havelaar et al (1984) based on studies in Netherlands, have reported that *untreated* poultry processing waste-streams contain on an average 10^4 PFU (plaque forming units)/ml of RNA coliphages, and 10^5 CFU (colony forming units)/ml of fecal coliforms in addition to lower levels of fecal streptococci and clostridial spores. Microbial numbers from a Canadian poultry processing plant contained on an average 10^4 CFU/ml of fecal coliforms, and 10^4 CFU/ml of fecal streptococci and 10^3 CFU/ml of *Aeromonas hydrophila*. *Salmonella* spp. have also been isolated from poultry wastewater (Menon, 1985).

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EGG PROCESSING PLANT BACTERIAL DISTRIBUTION

Michael T. Musgrove, Ph.D.
Poultry Processing and Meat Quality Research Unit
Richard B. Russell Research Center
950 College Station Road
Athens, GA 30605

Introduction

Hazard Analysis and Critical Control Point (HACCP) management systems are used by the U.S. Department of Agriculture (USDA) Food Safety and Inspection Service (FSIS) and the U.S. Food and Drug Administration (FDA) to ensure the safety of meat, poultry, seafood, and other foods (*48*). The effectiveness of HACCP relies heavily upon published scientific data. Currently a voluntary quality-based egg inspection system is administered by the USDA Agricultural Marketing Service (AMS) (*50, 51*). However, FSIS is currently drafting HACCP documentation for the shell egg processing industry that will be similar to regulations already in place for meat and poultry plants (14). A great deal of work has been published on the effect of processing on broiler carcass contamination (*1, 7, 18*). As a result, step-by-step fluctuations in various microbial populations on broiler carcasses have been determined. This has assisted researchers, industry, and regulators in developing HACCP plans in their efforts to decrease contamination of poultry meat with human pathogens (*48*). However, comparable information for shell egg processing facilities is not currently available.

Large scale processing of shell eggs began in the 1940s (*2, 36, 44, 52*). At that time, eggs were often soaked before being scrubbed and stored for long periods of time prior to sale. Many researchers noted that this practice was conducive to microbial cross-contamination and compromised quality and safety. At times, eggs were found to have higher bacterial counts after washing than before. Commercial shell egg production and processing in the U.S. have undergone a great deal of change in the last 60 years; particularly since the Egg Products Inspection Act was enacted in 1970 (*50*). The importance of wash water temperature, pH, iron levels, sanitizer/detergent selection, and minimizing bacterial numbers in wash water have been recognized (*2, 36*). Also, larger operations that utilize high speed washing and packing machines are routinely used by the shell egg industry (*52*). Now that effective processing conditions have been established, a thorough study of their effects on egg quality and safety need to be evaluated. Other researchers in recent years have focused on a single population at a limited number of points along the processing chain (*6, 15, 16, 21, 25, 29, 30, 37, 38, 39*). We conducted a study that has provided in-depth information on how bacterial populations associated with shell egg surfaces fluctuate throughout modern commercial processing. Populations were chosen because of their significance in terms of quality, process hygiene, or safety (*8, 31, 40, 44, 49*).

Materials and Methods

Description of shell egg processing plants.

A survey was conducted of in-line egg processing facilities. Three plants were selected for sampling on three separate processing days. These plants were designated as X, Y, and Z to protect the anonymity of the participating companies. Plant X was over 20 years old with a 135,000 eggs/h production capacity. Mixed operations (in-line and off-line) were processed though only in-line eggs were being processed during collection. Plant Y was an in-line operation, less than 3 years old, and processed approximately discarded and the inside of the shell was rinsed using sterile PBS to remove most of the adhering albumen. An effort was made to eliminate as much of this material as possible because of the antimicrobial components of albumen. Shell and membranes from a single egg were crushed in a gloved hand and forced into a sterile 50 ml disposable centrifuge tube. After 20 ml of sterile PBS was added, a sterile glass rod was moved vertically in and out of the tube for 1 min. This allowed for a maceration of shells and membranes as well as a thorough mixing of the sample with the diluent. Rinsate from every egg was then subjected to microbiological analyses.

Direct plating microbiology.

Bacterial populations from individual samples obtained with this method were enumerated for total aerobes, yeasts and molds, *E. coli*, and *Enterobacteriaceae*. Aerobic populations were enumerated on plate count agar (PCA) after incubation at 35°C for 48 h. Yeasts and mold counts were determined on dichloran rose bengal chloramphenicol (DRBC) agar plates incubated at 22-25°C for 5 d. *Escherichia coli* were enumerated on Petri-film plates (blue gas producing colonies), incubated at 35-37°C for 18-24 h. *Enterobacteriaceae* were enumerated on violet red bile glucose gar (VRBGA) plates with overlay (purple-red colonies). Plates were incubated at 37°C for 18-24 h. Presumptive colonies were counted and reported as $\log_{10}$ CFU/ml egg rinse or contents.

***Salmonella* enrichment.**

For each of the twelve collection sites, two pooled samples were formed by combining shell egg rinses or crushed shells and membranes from five eggs. Samples were pre-enriched in buffered peptone water at 35°C for 18-24 h, followed by enrichment in TT broth and Rappaport-Vassiliadis broth overnight at 42°C. Enriched samples were plated onto BG Sulfa and XLT-4 agar plates and incubated at 37°C for 24 h. Presumptive positives were inoculated into lysine iron agar (LIA) and triple sugar iron (TSI) slants and incubated at 35°C for 18-24 h. Those samples giving presumptive results on each of these media were confirmed using sero-grouping anti-sera. Confirmed isolates were then streaked for purity and stocked onto agar slants and ceramic beads in cryogenic protective media. A copy of each isolate was provided to the National Veterinary Services Laboratory of the USDA's Animal and Plant Health Inspection Services in Ames, Iowa for serotyping. A sample was recorded as positive if it was confirmed and sero-typed from either of the shell rinse or crushed shell and membrane composite samples.

Statistical Analyses.

Population data were analyzed using the general linear model of SAS (*45*). Means were separated with the least-squared means option of the general linear model procedure of the SAS/STAT program using significance levels of $P < 0.05$ (*45*). A comparison of recovery frequency was accomplished by Chi-square test of independence (*45*).

Results

All the populations surveyed decreased throughout processing in every plant. Population data collected at each of the twelve processing sites for aerobic microorganisms, yeasts/molds, *Enterobacteriaceae*, and *E. coli* are presented in Table 1. Values are averages for all three visits of the three plants sampled. For all populations, greatest numbers of organisms were recovered from shell rinses of eggs collected at the accumulator or the re-wash belt. Pre-wash counts were higher than those obtained from eggs at most other sample collection sites (in-process and post-process).

Discussion

Much of the literature published on the microbiology of shell egg processing was published before the 1970s (*9, 10, 11, 12, 13, 22, 44, 52*). This information was vital to shaping the successful practices currently used today. Recent work has focused on the efficacy of particular detergents, sanitizers, or antimicrobial treatments such as UV radiation (*6, 15, 26, 32*). Other researchers have focused on how processing conditions affect *Salmonella* Enteritidis, the most prevalent serotype associated with foodborne illness in recent years. Many of these studies made use of inoculated eggs. Several researchers have used empirical data to construct useful models for determining the effects of variations in processing parameters on microbial populations associated with shell eggs or wash water (*6, 33, 46, 47*). Models and empirical studies are of tremendous value in defining problems and formulating their solutions. However, experimental design and statistical tools are not adequate to fully describe or include all parameters that affect microbial growth or survival. For these reasons, data collected from field or plant situations are important. Several studies in recent years have described shell processing and distribution though they tend to focus on production or distribution for a single population (*15, 21, 29, 30 41*). Our study was conducted to provide an intensive analysis of the effects of each stage of processing for five microbial populations that affect shell egg quality or safety.

There were some differences in microbial levels recovered from egg shells collected at different plants on different visits (replications). Each plant was visited within two weeks of each other in sequential fashion to prevent a seasonal bias. Prior to processing, aerobic microorganisms, *E. coli*, and yeasts/molds were determined to be less than a $\log_{10}$ CFU/ml rinse different among the plants. Despite differences in age, processing capacity, and water quality, all three plants were contaminated at comparable levels for yeasts/molds, *Enterobacteriaceae* and *E. coli* at the end of processing. For this reason, most of the data will be discussed as averages among the three plants.

Plant X was significantly ($P < 0.05$) more contaminated with aerobic microorganisms than Y or Z by greater than 2 $\log_{10}$ CFU/ml rinse for eggs that were ready to be packaged. Aerobic plate counts are a gauge of sanitary quality and adherence to good manufacturing practices (*40*). Plant X was the oldest plant with the highest production capacity, lowest average wash water pH (10.0 v. 10.3 and 11.2 for plants Y and Z), and with the least hygienic product flow. Pre-wash rinsing had less effect for all populations than was observed for the other two plants. For plant X only, none of the directly plated populations decreased by a log until eggs reached the first washer. There was also a great deal of foaming noted during the first visit to plant X. Excessive foaming is one of the wash water parameters recommended in the Agricultural Marketing Service list of guidelines (*51*). Knape et al. (*30*) compared aerobic microbial counts for shell egg surfaces between in-line and off-line operations. They determined that counts were almost a log higher per egg for in-line eggs. All eggs sampled in this study were collected during in-line processing though plants X and Z also process off-line eggs. Perhaps greater contamination of equipment surfaces, wash water, and plant environment occur at plants where off-line eggs are processed. Based on surveys of commercial shell egg plants, Moats (*39*) concluded that bacteria on equipment surfaces were the most important sources of egg shell contamination. Plant Z maintains the highest pH levels in their washer water (> 11). This may have allowed plant Z to decrease aerobic microbial levels equivalent with plant Y which had the lowest overall microbial contamination on the unprocessed eggs.

Plants X and Z re-wash sound eggs that are visibly dirty. When re-washing is incorporated into a plant's processing chain, an egg will either become visibly clean or break. This practice means that a higher proportion of visibly dirty eggs will be passed through the washers. Before parameters known to limit microbial contamination of wash water were determined, it was recommended that dirty eggs not be re-washed. It was thought that re-washing visibly dirty eggs would increase microbial counts in the wash

Once eggs were introduced into the washer, microbial populations were reduced and biologically significant increases were not observed through the remainder of the processing chain. Sanitation affects microbial populations during shell egg processing. Certain sections of the equipment are not water proof (scales), are difficult to reach (re-wash belt), or are difficult to remove and clean regularly (packer head brushes). However, contact with these surfaces did not result in significant increases in counts.

Salmonella is considered the most important human enteropathogen associated with shell eggs (*2, 44, 49*). *S.* Enteritidis is the serotype most often implicated in egg-borne outbreaks of salmonellosis though product temperature abuse followed by consumption of raw or undercooked eggs are usually factors. This serotype occurs at a low frequency (1 in 20,000 eggs) even when flocks are known to be *S.* Enteritidis colonized. However, all serotypes of *Salmonella enterica* are potential human pathogens and their presence on eggshells is of interest (*49*).

In our study, we obtained 39 *Salmonella* isolates from egg shell rinses, tap water, and wash water. Individual plant visits yielded 0 – 25 *Salmonella* isolates. Except for X1, 0 – 4 isolates were obtained per plant visit. Between both shell rinse and crush methodologies, 35/396 (8.8%) samples were positive for *Salmonella* following enrichment. Jones et al., (*29*) found 8/180 (4.4%) of egg shell rinses *Salmonella* positive. Prior to processing there were 7.8% (7/90) *Salmonella* positive rinses while post-processing rinses were only 1.1% (1/90) positive. March (*35*) and Cox and Davis (*17*) did not recover *Salmonella* from 3,995 and 264 individual egg samples, respectively. During X1 sampling 1/3 of the tap water samples were determined to be contaminated with *Salmonella.* Plant X was the oldest plant (> 20 y old) included in the study and unchlorinated well water was used for processing. Potentially some animal (insect, amphibian, reptile, or mammal) may have compromised biosecurity and contaminated the plant's well water or it may have been caused by some other random event. This phenomenon was not observed again at plant X. It was never observed at plants Y and Z. *Salmonella* prevalence at this plant on other visits (X2, X3) was similar to that observed for other plant-visits (Y1-3, Z1-3). *Salmonella* prevalence for X2 and X3 averaged 6.25% (6/96) and 4.0% (10/252) for all other plant-visits, respectively. *Salmonella* were recovered from egg rinses collected during pre-process (10/28) more often than from in-processing (10/42) or post-processing stages (6/27). This data is evidence that commercial processes reduce *Salmonella* contamination of eggshells. Plant-visits in which *Salmonella* was recovered from eggshell rinse samples post-process were X1, Y2, Y3, and Z2.

Wash water parameters that are thought to influence *Salmonella* survival are temperature, pH, organic material, and iron levels. In addition to contaminated tap water, X1 was the plant-visit with the lowest average temperature and one of the only times where wash water pH was ≤10. Jones et al. (*29*) and Catalano and Knabel (*15*), detected *Salmonella* in shell rinses when the wash water pH was at the lowest measure (10.19). However, lowest pH was recorded for X2 (9.1) and Y1 wash water pH was 10. Average wash water temperature for all 9 plant-visits and both washers was 42.6 C. Three of the four plant visits where *Salmonella* was recovered post-process had wash water at or below that figure. Highest COD values were determined for all plant Z visits and the highest total solids figure was for Z3, iron levels were over 2 ppm for X3 yet *Salmonella* was only recovered from post-process samples from Z2. As determined from models derived from empirical data, a combination of factors affect whether or not *Salmonella* will survive shell egg processing. Hurdle technology has been built into the AMS guidelines and should be considered when writing HACCP plans for shell egg washing plants (*34*).

Five different serotypes from sero groups B and C were isolated from samples collected in our project. *S.* Enteritidis, of sero group E was not recovered. In a national survey, Garber et al., (*24*) did not isolate this serotype from production or processing samples collected in the southeastern United States. *Salmonella* serotypes recovered by Jones et al. (*29*) from eggshells prior to processing were *S.* Heidelberg and *S.* Montevideo. Production serotypes were identified as *S.* Agona, *S.* Typhimurium, *S.* Infantis, *S.* Derby, *S.* Heidelberg, *S.* California, *S.* Montevideo, *S.* Mbandaka, and untypeable. Poppe (*43*) isolated *S.*

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AIRBORNE MICROBIAL CONTAMINATION OF SHELL EGG AND QUAIL FACILITIES

Julie K. Northcutt, Ph.D
USDA, Agriculture Research Service
P.O. Box 5677, Athens, GA 30604-5677
Ph: 706-546-3592; Fax: 706-546-3633
jnorthcutt@saa.ars.usda.gov

In a food processing environment, airborne microorganisms can be a major source of product and surface contamination. These bacteria may originate from workers, bird dander, feathers, fecal material, solid waste, wastewater, and dust (Al-Dagal and Fung, 1990; Ellerbroek, 1997; Lutgring et al., 1997; Northcutt et al., 2004). Bacteria may also become aerosolized during cleaning and sanitation of the facility, as high volumes of water hit contaminated surfaces and flood the drains. Other factors that may have a significant effect on airborne bacteria in processing facilities are air flow, air distribution, temperature, relative humidity, design of the facility and facility maintenance (Lutgring et al., 1997). Previous research on airborne microbial populations and aerosol production in the poultry industry has been limited and the information that is available has focused on broiler houses, hatcheries, broiler processing facilities and turkey processing facilities. The two studies described in this proceedings were conducted to characterize the amount and distribution of airborne bacteria in commercial shell egg and quail processing facilities.

Air Sampling Methodology

During both the shell egg and quail experiments, air was sampled using MicroBio MB2 Air Samplers (F. W. Parrett Limited, London, England) which were attached to standard camera tripods and set to a height of 91.4 cm (center of sampling head). The air samplers were set to draw air for 10 min (1000 L of air) directly on to Rodac plates containing 5 mL of sterile Brain Heart Infusion (BHI) agar. After sample collection, the agar was blended with 10 mL of phosphate buffered saline (PBS) and the blended mixture was plated onto other specialized media.

In the commercial egg processing facilities, air was sampled in three facilities that were using different line operations (in-line, off-line, and mixed operations). Air sampling sites included areas in or near the following locations: hen house (in-line and mixed operations), farm transition room (in-line and mixed operations), egg washers, egg dryer, packer head, post-processing cooler, nest-run cooler (off-line and mixed operations), loading dock and dry storage area. Air was evaluated for total aerobic bacteria, molds/yeasts, coliforms and pseudomonades.

Air was also sampled in a vertically integrated Japanese quail operation at six production-related sites and six processing-related sites. Production-related sampling sites included the grow-out and breeder houses along with the hatchery setter, hatcher, egg room and chick room. Processing-related sites included the hanging/stunning area, scalding/defeathering room, evisceration line, chiller exit, further processing area and shipping room. Samples from the quail production/processing facility were evaluated for total aerobic bacteria, molds/yeasts, *E.coli* and *Enterobacteriaceae*.

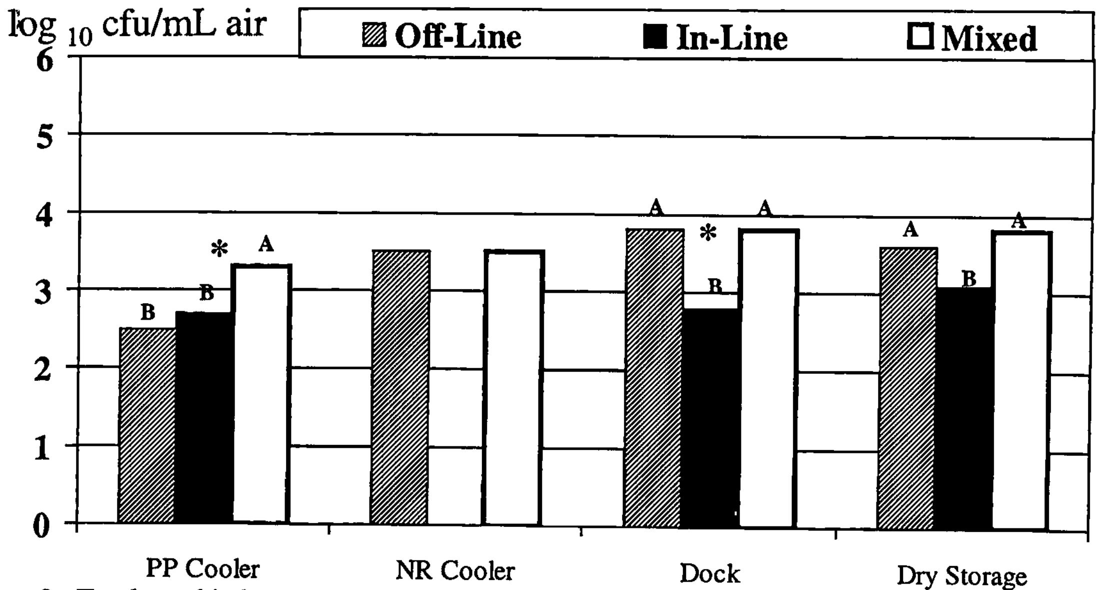

Figure 2: Total aerobic bacteria found in the air in the post-processing cooler (PP cooler), nest-run cooler (NR cooler), loading dock (Dock) and dry storage area (Dry storage) in commercial shell egg processing facilities (off-line, in-line or mixed operations) (N=12; $P < 0.05$).

Figures 3 and 4 shows the airborne counts for molds and yeasts at the different sampling sites in commercial shell egg processing facilities. Differences in molds/yeasts counts were minimal (< 0.5 $\log_{10}$ cfu/mL air) among the types of operations when samples were collected in or near the hen houses, farm transition rooms, egg washers, egg dryers, packer heads, post-processing coolers and nest-run coolers.

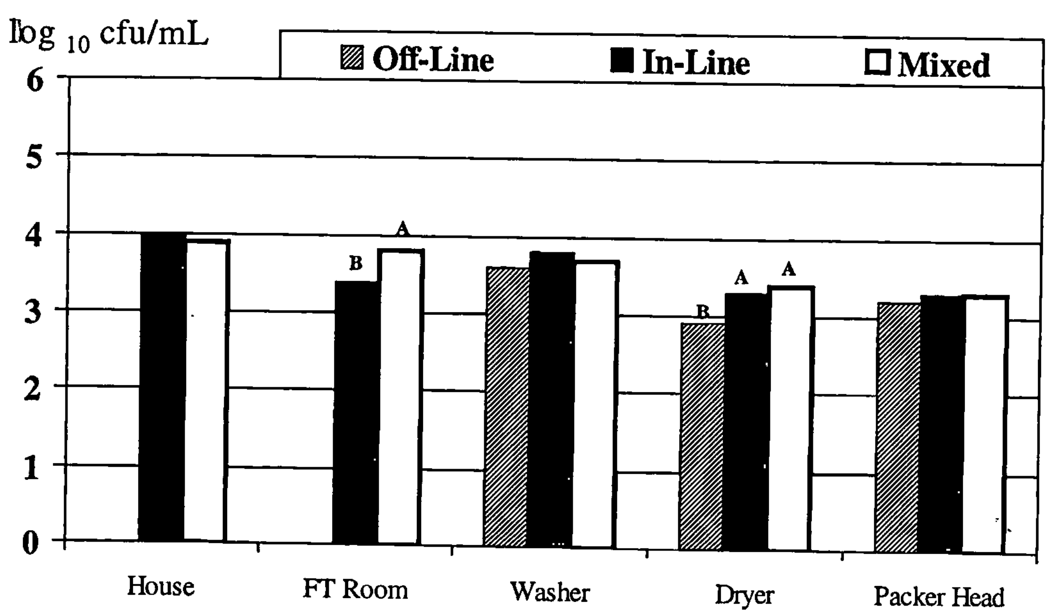

Figure 3: Molds/Yeasts found in the air in the layer house and farm transition room (FT room), or behind the egg washer, dryer, and packer heads in commercial shell egg processing facilities (off-line, in-line or mixed operations) (N=12; $P < 0.05$).

coli (1.9 $\log_{10}$ cfu/mL) and *Enterobacteriaceae* (2.3 $\log_{10}$ cfu/mL) were greatest in the grow-out house (Table 1). This is likely due to the number of quail in each house which ranged from 110,000 to 121,000 birds. Among the production-related sampling sites, counts for total aerobic bacteria gradually decreased and were lowest in the setter (3.9 $\log_{10}$ cfu/mL), hatcher (3.8 $\log_{10}$ cfu/mL) and chick room (3.5 $\log_{10}$ cfu/mL). Molds/yeasts measured at the production-related sampling sites followed a similar pattern with lowest counts in the egg room (2.0 $\log_{10}$ cfu/mL), setter (2.1 $\log_{10}$ cfu/mL), and hatcher (2.3 $\log_{10}$ cfu/mL). *E coli* counts varied by less than 0.5 $\log_{10}$ between the grow-out houses and the breeder house (1.5 $\log_{10}$ cfu/ml air), and *E. coli* was not detected at any of the other production-related sites. Counts for *Enterobacteriaceae* varied by 1.0 $\log_{10}$ cfu/mL among the production-related sampling sites with the lowest counts in the breeder house and setter.

TABLE 1: Effects of sampling site on $\log_{10}$ counts (cfu/ml air) and prevalence of airborne total aerobic bacteria, molds/yeasts, *E. coli* and *Enterobacteriaceae* during the production of Japanese quail

Sampling Site	Total aerobes[1]	Molds/yeasts	*E. coli*	*Enterobacteriaceae*
Grow-out house	8.1^a	3.6^a (24/24)	1.9^a (24/24)	2.3^a (24/24)
Breeder house	4.8^b	2.9^b (24/24)	1.5^b (22/24)	1.3^c (22/24)
Egg room	4.1^c	2.0^d (20/24)	NA[2] (0/24)	NA (0/24)
Hatchery setter	3.9^c	2.1^d (14/24)	NA (0/24)	1.2^c (4/24)
Hatcher	3.8^c	2.3^{cd} (14/24)	NA (0/24)	1.7^b (8/24)
Chick room	3.5^d	2.5^c (8/24)	NA (0/24)	2.0^{ab} (4/24)

[a - d] Means ± standard error in the same column without common superscripts are significantly different ($P < 0.05$).

[1]Prevalence (number of samples testing positive out of the total number of samples) for all sampling sites for total aerobic bacteria was 24/24 (4 samples per site for each of 3 replications in duplicate).

[2]NA indicates that no bacteria were detected (prevalence of 0/24).

In the processing facility, counts of airborne total aerobic bacteria were greatest in the hanging/stunning (6.8 $\log_{10}$ cfu/ml air) and scalding/defeathering (6.7 $\log_{10}$ cfu/ml air) areas (Table 2). These levels decreased by over 3.0 $\log_{10}$ as the quail moved into evisceration, but levels increased thereafter by 0.5 (shipping) to 1.1 $\log_{10}$ cfu/ml (chiller exit). The increase in airborne bacteria around the chiller may be due to a nearby door that connects this area with the scalding/defeathering room. Similarly, levels may be higher in the shipping room because this is the area where all of the employees enter/exit the facility. For all of the processing-related sampling sites, levels of molds/yeasts, *E. coli* and *Enterobacteriaceae* varied by 0.5 $\log_{10}$ cfu/ml air or less. The highest level of molds/yeasts was found in the shipping room (2.8 $\log_{10}$ cfu/ml air), but this could be coming from the air outside the facility. *E. coli* was not found in the air near the chiller exit, further processing room or shipping room.

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FSIS REGULATIONS FOR REUSE OF WATER IN POULTRY PROCESSING

B. P. Dey[1], Alice Thaler[2] and Jim Heminover[3]
United States Department of Agriculture,
Food Safety and Inspection Service

[1,2] Office of Public Health Science, Zoonotic Diseases and Residue Surveillance Division, Washington, D.C. 20250
[3] Office of Policy, Program, and Employee Development, Technical Service Center, Program Analysis Staff, Omaha, NE 68102

The Food Safety and Inspection Service (FSIS) is the public health regulatory agency responsible for the inspection of processed meat, poultry and egg products to ensure wholesomeness and safety. Poultry processing relies heavily on the use of water for carcass washing, sanitation and disinfection of processing plants and equipment. Additionally, water is used in further processing operations such as cut-up, breading, cooking, etc.

Water flow physically rinses contaminants off birds and as a medium, water delivers antimicrobial agents. The effectiveness of microorganism removal from birds improves as the contact time with water and antimicrobial agents increases.

Poultry processing operations are regulated by the United States Department of Agriculture's Food Safety and Inspection Service (USDA-FSIS). Regulations require a specific water usage in some operations for each bird processed (i.e., chilling, scalding, etc.). Additionally water usage in many other processing operations is needed such as hand wash stations, and inside/outside bird washers.

The Food Safety and Inspection Service's (FSIS') introduction of the Hazard Analysis and Critical Control Points (HACCP) regulations, and required compliance with a zero tolerance policy for fecal contamination, created an increase in water use during poultry processing. To conserve water while still ensuring food safety and meeting the increased demand, reconditioned water for direct product contact has been allowed in poultry processing.

Initially, recycled water was primarily allowed only for non-product contact applications, such as vacuum pump cooling water; feather flume flushing; and dock washing. During the late 1970's up to January 25, 2000, the agency extended the reuse of water on product contact application with prior approval by the agency.

The issuance of the USDA Sanitation Requirements for Official Meat and Poultry Establishments, CFR 416.2(g) (1-6), and the Sanitation Performance Standards Compliance Guidelines, published January 25, 2000, considered water usage and conservation. Under the Sanitation Performance Standards, poultry processors are allowed without prior approval to utilize properly reconditioned water for direct product contact. FSIS Sanitation Performance Standards Compliance Guidelines for water, ice and solutions reuse are not requirements but provide methods that poultry establishments could use to meet the Sanitation Performance Standards Regulations. The Compliance Guidelines have descriptions and conditions for reuse of ice, brine, cook and chill water, propylene glycol, chiller overflow water, condenser or

(4) Reconditioned water that has never contained human waste and that has been treated by an onsite advanced wastewater treatment facility may be used on raw product, except in product formulation, and throughout the facility in edible and inedible production areas, provided that measures are taken to ensure that this water meets the criteria prescribed in paragraph (g) (1) of this section. Product, facilities, equipment, and utensils coming in contact with this water must undergo a separate final rinse with non-reconditioned water that meets the criteria prescribed in paragraph (g)(1) of this section.

(5) Any water that has never contained human waste and that is free of pathogenic organisms may be used in edible and inedible product areas, provided it does not contact edible product. For example, such reuse water may be used to move heavy solids, to flush the bottom of open evisceration troughs, or to wash ante-mortem areas, livestock pens, trucks, poultry cages, picker aprons, picking room floors, and similar areas within the establishment.

(6) Water that does not meet the use conditions of paragraphs (g)(1) through (g)(5) of this section may not be used in areas where edible product is handled or prepared or in any manner that would allow it to adulterate edible product or create unsanitary conditions.

REGULATORY STANDARDS

The FSIS Sanitation Performance Standards require that potable water comply with EPA's National Primary Drinking Water regulations. These regulations are promulgated under section 1412 of the Public Health Service Act, as amended by the Safe Drinking Water Act, and are applicable to public water systems. The EPA standard of water potability is sufficient to ensure food safety.

The EPA National Primary Drinking Water regulations, contained in 40 CFR part 141, require testing of drinking water for fecal coliforms and other contaminants at specified frequencies. Because FSIS is requiring that water used by meat and poultry establishments meet the EPA requirements, which include testing requirements, FSIS did not promulgate separate testing requirements. Certifications of water potability provided by State or local governments or other responsible entities will show whether water meets the EPA requirements.

Some meat and poultry establishments use private wells for their water supply. EPA classifies private wells as "non-community" water sources and does not require testing for potability. It also is unlikely that State or local governments would test such wells for potability. If an establishment uses a private well, FSIS requires that the establishment make available to FSIS documentation, renewed at least semi-annually, certifying the potability of its private well water. Most establishments will obtain this documentation from private laboratories.

In many circumstances, establishments can reuse water in a manner that will neither adulterate product nor create unsanitary conditions. For example, water can be recirculated in tanks to chill raw poultry; water treated by an advanced wastewater treatment system can be used to wash equipment or raw product, if followed by a potable water rinse; and nonpotable, reuse water can be used to wash floors or equipment in areas where edible product is not handled. FSIS performance standards provide for the reuse of water in numerous processing contexts, provided that the establishment takes actions necessary to ensure that product is not adulterated by the water and that sanitation is not compromised. Establishments are anticipated to document and monitor water reuse activities either in their Sanitation SOP's or HACCP plans.

6. **Condenser or Compressor Water Reuse:** Water from condensers or compressors may be reused in edible and inedible product areas providing that it is maintained pathogen free.

7. **Reuse Water to Flume Chicken Feet**: Poultry chiller overflow water and water used to flume chicken feet (paws) may be used to flume chicken feet including through an in-line paw chiller.

8. **Reuse Water to be Used to Wash Livestock Pens, Trucks, Poultry Cages and Similar Areas**: Water from an establishment's secondary and tertiary wastewater treatment facility or other processing water may be reused to wash livestock pens, trucks, poultry cages, and other similar areas.

9. **Reuse Water to be Used to Wash Inedible Product**: Water from throughout the plant may be reused in inedible product areas (i.e. washing offal sump screens, flushing feather flow-away troughs, flushing eviscerating troughs that are covered with metal plates, etc.).

10. **Reuse Water from an Advanced Waste Water Treatment Facility**: Reuse water from an advanced wastewater treatment facility may be used on edible product (but not in product formulation) and throughout the plant in edible and inedible production areas.

11. **Reuse Water in Vapor Lines from Deodorizers**: Water in vapor lines from deodorizers (condensers) used in preparation of lard and similar edible product may be reused for the same identical use.

12. **Reuse Water from single or Multiple Point Sources Can be Used for Single or Multiple Point Source In the Slaughter Process**: Reuse water from any slaughter process location(s) (e.g., scalder, inside/outside bird washer, chiller overflow water, etc.) can be used at any location(s) in the slaughter process including for the chiller make-up water and for general sanitation purposes.

COMMENT

FSIS has allowed reuse of water in poultry industry to conserve water resources with due consideration that such practices do not cause food safety risks. The poultry processing industry has made significant strides in implementing effective water conservation and reuse programs. Since HACCP, many plants have reduced the total amount of water usage. It is estimated that about 50% to 60% of water used per bird processed, is being reused. FSIS verifies that water reuse does not adulterate product or cause unsanitary condition that could cause a public health risk.

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WASTEWATER MINIMIZATION: PARTICLE SIZE DIFFERENTIATION

Brian Kiepper
Research Engineer
UGA Engineering Outreach Service
Driftmier Engineering Center
University of Georgia
Athens, GA 30602

Ph: 706-542-6907; Fax: 706-542-8806
bkiepper@engr.uga.edu; http://www.engr.uga.edu/service/outreach/

William C. Merka
Daniel L. Fletcher
Poultry Science Department

Jackie Sellers
Biological & Agricultural Engineering Department

Introduction

Rationale for research in the area of particle size differentiation of poultry processing wastewater centers on the need for the consistent examination of wastewater characteristics, treatment practices and residuals handling within the rapidly growing U.S. poultry meat processing industry. The need for these regular scientific assessments stem from the phenomenal growth of the poultry industry that continues to increase at an annual rate of approximately five percent (Kiepper, 2003). The processing industry has responded to this growing demand with larger plants, faster processing line speeds, and more employees. A typical chicken processing plant in 1992 produced approximately five times more output than a plant in 1967. Also, instead of producing mostly whole birds, plants today generate a product mix of tray packs of cut-up parts, bulk containers of deboned meat, and other further processed products (Ollinger *et al.*, 2000).

Since 1972, following the implementation of the Clean Water Act and subsequent creation of the U.S. Environmental Protection Agency (EPA), poultry meat processors have been required to continually improve the treatment of their wastewater prior to effluent discharge. At the same time, poultry plant water use has risen in response to food safety protocols such as the Hazard Analysis Critical Control Point (HACCP) and the Zero Tolerance for fecal material programs. This increased generation of wastewater requires more efficient removal of by-products and pollutants that will allow for effluent discharge within established environmental regulatory limits (Kiepper, 2003).

A typical poultry slaughter facility processing 200,000 birds a day, weighing an average of 5.5 pounds live weight and with a typical carcass yield of 72 percent, will produce approximately 308,000 pounds of offal each day (Lortscher et al., 1957; Ockerman and Hansen, 2000). Typical offal handling systems, consisting of primary and secondary physical screens, can be expected to remove only about 60 percent of the offal in the form of macro-solids from the wastewater flumes (feather and viscera) exiting the production floor. These macro-solids are recovered as unadulterated primary offal for sale to the rendering industry. The remaining 40 percent of smaller (usually below 500um or 'micron' in size), particulate solids (approximately 100,000 pounds of wet weight solids or approximately 25,000 pounds of dry weight solids in the example above) and dissolved solids travel with the wastewater stream to

In addition, results of previous technical assistance work by UGA researchers have shown the direct relationship between wastewater stream strength and process efficiency. Development of methods for determining process efficiency through waste stream analysis will not only reduce environmental impact and costs, but also enhance plant profits by increasing product utilization in its highest value form. Some examples of this relationship include:

- a wastewater stream analysis of a broiler processor that revealed the plant was discharging more than 13 percent of bird live weight in the plant effluent,
- the creation of more than one million dollars a year in additional profits for a further processor producing broth, fat and meat from spent breeding stock, by using wastewater stream monitoring to pinpoint times and process operations that created the highest strength waste streams, and
- revealing that a further processor that produces breaded fried chicken products discharged over 3,300 pounds of dry weight product to their wastewater stream each day.

Poultry Processing Wastewater Screening

The most common first treatment method used by U.S. poultry processors to remove gross solids and particulate matter from wastewater streams is physical screening (Kiepper, 2001). Screening serves two main purposes. First, screening recovers offal materials (feathers, viscera, meat particles) that are valuable by-products for the poultry rendering industry. Second, screening prepares wastewater for further treatment by removing large particulate pollutants that might otherwise impede the operation and maintenance of downstream equipment and treatment processes. Screening is often the first, simplest and most inexpensive form of wastewater treatment (Kiepper, 2001).

Screening is defined as the physical removal of particulate matter from a waste stream by the insertion of a perforated surface or 'screen' that retains particles larger that the screen openings and allows the flow through of smaller particles and wastewater. Screen opening size and flow rate capacity are the most important criteria used to select a screen for operation in a poultry processing plant (Pankratz, 1995). The most common problems associated with screens are mechanical failures and blinding due either to the overloading of the screen or to under sizing of screen gaps. Blinding is defined as the overloading of a screen that results in the coating over of the open spaces, preventing the pass-through of water.

Screens are classified by the size of the open spaces that allow the passage of water. Screens are classified as coarse, fine, very fine and micro. Table 1 shows the range of space openings for each screen size (WEF, 1998).

Table 1. Wastewater Screen Classifications by Open Space Sizes

Type	Inches (in)	Millimeters (mm)	Microns (um)
Coarse	> 0.25	> 6.0	> 6000
Fine	0.059 – 0.25	1.5 – 6.0	1500 - 6000
Very Fine	0.008 – 0.058	0.2 – 1.49	200 - 1499
Micro	$3.9 \times 10^{-8} - 1.2 \times 10^{-2}$	0.001 - 0.19	1 - 199

Screens are also classified by their form and mechanical function (bar, static, shaker, rotary). Bar screens have limited applications in poultry processing facilities due to the relative large openings that remove exiting the typical secondary screen gap opening size of ~500 micron, will be isolated between 75 and 125 micron. Each solid sample underwent proximate analysis to determine the percent moisture, protein, fat, crude fiber and ash. This information will be used to make comparisons both within individual plants over time and between plants based on proximate analysis and other data collected during this research project.

At the time of the submission of transcripts for publication, the data collection phase of this research work had just been completed. Detailed information pertaining to these results will be presented at the conference.

Particle Size Differentiation Method 2: LASER DIFFRACTION (LALLS)

Particle Size Analysis of Fluids

The scientific study of sub-sieve particle size differentiation in fluids can be traced back to particle settlement studies in the early 1900's. Scientists, utilizing engineered decanting devices, were able to accurately classify sub-sieve particles in fluid columns, although the method was time consuming and required close attention during regular intervals (Haywood, 1972). Also, this method could not account for emulsions, in which particles of a sufficient small size can remain suspended indefinitely.

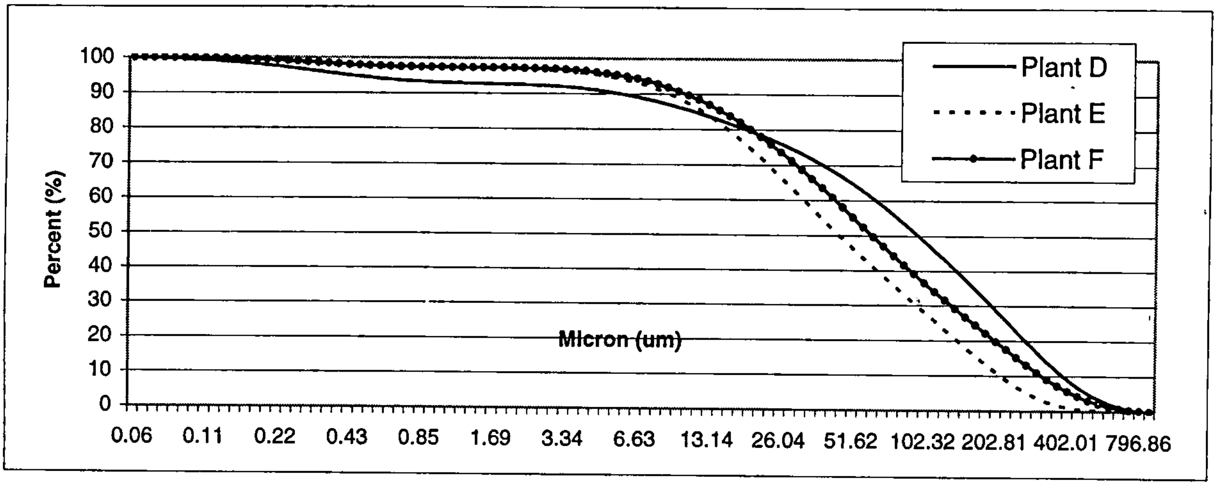
Also at the turn of the century, scientists were developing light-scattering techniques based on the principle that illuminated particles serve as secondary radiation sources in a manner relative to their size (Irani and Callis, 1963). However, calculations for even monodispersed fluids were so complex that the wide use of the technique was impractical. Then, in the 1960's, the development of the laser sparked a proliferation of light scattering experiments (Dalgleish and Hallett, 1995). Based on this work, several scientists (Conillault, 1972; Weiss and Frock, 1976; Swithenbank *et. al.*, 1977) developed techniques of inferring size distributions of fine particles from the angular distribution of the intensity of forward-scattering coherent light. This work led to the development of the first commercial laser diffraction sizing units (Agrawal *et. al.*, 1991). The original units utilized the Fraunhofer diffraction approximation, which is only applicable to particles that are large relative to the wavelength of light (de Boer *et. al.*, 1987). Today, laser diffraction instruments utilize a combination of Fraunhofer diffraction and the full Mie scattering theory (1908) to deal properly with particles in the fine to micro particle range.

Low Angle Laser Light Scattering (LALLS)

Laser diffraction, more accurately referred to as Low Angle Laser Light Scattering (LALLS), is quickly becoming the preferred standard in many industries for the measurement of particles in the 0.1 to 2000um range. LALLS operates on the principle that as a particle passes through a laser beam it causes light to be scattered at an angle that is inversely proportional to its size. A detector captures the scattered light and analyzes the diffraction pattern, enabling the calculation of particle size distribution in a given sample. Within certain limits, the scattering pattern of a group of particles is the same as the sum of individual scattering patterns of all the particles (Rawle, 2001).

LALLS instruments, such as the unit used in this project, consist of a laser (a source of coherent intense light of fixed wavelength. He-Ne gas lasers (λ = 0.63um), which offer the best stability and signal strength, are most commonly used), a detector (usually a slice of photosensitive silicon with a number of isolated detectors on its surface, and a sample transportation device (a means of passing the sample

Graph 2. Further Processing Plants Cumulative Percentage of Particles by Volume (0.05 - 900um)



Particle Size Differentiation Method 3: HISTOLOGICAL DIFFERENTIATION

The UGA particle size differentiation research team is currently working in conjunction with Dr. Susan M. Williams, a veterinary pathologist with the UGA College of Veterinary Medicine's Poultry Diagnostic and Research Center to develop a method of fixing particulate matter recovered from the wet sieving technique for histological examination. This method will be used to determine the various types and quantities of tissue particles collected at each sieve fraction. The method utilizes formalin fixation, differential staining and microscopic analysis to isolate and identify each type of tissue particle. The data from this method will be used to isolate individual mechanical devices and production operations within processing plants that contribute the largest particulate matter loading to wastewater streams.

Particle Size Differentiation Method 4: PROTEIN ELECTROPHORESIS

The UGA particle size differentiation research team is also currently working in conjunction with Dr. Julie Northcutt, a research scientist at USDA-ARS, Athens, GA to develop a method using protein electrophoresis to identify the types of proteins found in tissues isolated in each sieve fraction. Protein electrophoresis is a method of separating different types of protein based on molecular weight. A mixture of protein molecules is extracted from the particulate matter collect on the sieves and placed at one end of a slab of gelatin-like material. The gel slab is then placed in a strong electrical field. All of the proteins are pulled toward the positive pole of the electric field, but because big molecules travel slowly through the gel matrix and small molecules travel more quickly, the proteins become separated according to their size. So that protein separation patterns can be determined, the gel columns are stained so that the band s of separation can be identified. Based on the specific band separation pattern, specific proteins (i.e. tissue type) can be determined. The typical proteins separated from poultry processing wastewater particulate matter will generally be from organ tissue, skeletal muscle (meat), and smooth muscle tissue (intestine). Other lesser sources of protein can be from connective tissue, skin, or minute feather particles.

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MICROBIAL INTERVENTIONS THAT IMPACT WASTE WATER

Helen G. Brown, PhD
Research Scientist
Food Safety and Research Laboratory
Tyson Foods, Inc.
Springdale, AR

Microbial interventions in use in poultry slaughter facilities include (but are not limited to) chiller applications and application of chemicals during online reprocessing (OLR). Antimicrobial chiller options include chlorine, hypochlorous acid, chlorine dioxide, monochloramine, peroxyacetic acid, and bromine (hypobromous acid). Additionally, acidified sodium chlorite can be applied after chiller as an antimicrobial. Various chlorine sources are used in poultry processes. Chlorine (sodium, calcium hypochlorite, chlorine gas) is used as a sanitizer @ 200 ppm. The largest continuous applications are in bird washers and make up chiller water @ 50 ppm. In the chiller chlorine is used up leaving < 3-5 ppm free (or residual) chlorine going down the drain. Consider how much chlorine may go into a water stream: a chiller has 140 gallons per minute going in; makeup water with chlorine is at a rate ~1/2 gallon per bird; hence 70 gpm is put into the chiller with 50ppm. Net chlorine going to waste water would be 70 gpm X 5 ppm maximum.

Chlorine dioxide is approved for use in poultry process waters at a rate of 1/10 that of total chlorine (i.e. 3-5 ppm). CLO2 is generated from either 2 or 3 chemicals and injected into different water applications, both for reprocessing and in chillers. Another chlorine source is hypochlorous acid where the pH is controlled via mixing CO2 and a hypochlorite source. Ideal disinfection value of chlorine is below pH 6.5; above that the chlorine is in the hypochlorous ion form, below pH 4 chlorine can gas off. Many municipalities use hypochlorous acid and ammonia to generate monochloramine for disinfection. Free chlorine can combine with organic compounds to produce organo-chloramines which are relatively insoluble and can cause odor problems in the plant. Poultry plants that receive chloraminated city water and then treat the water with a source of free chlorine chloramines generate mystery gasses that cause environmental issues to workers. The species of chloramine that is produced when combining ammonia and chlorine can be selected by controlling the chlorine to nitrogen (CL_2:N) ratio. To ensure that only monochloramine is formed, current practice is to use a Cl_2:N ratio in the range of 3:1 to 5:1, with a typical value of 4:1. Ratios less than 5:1 result in the presence of monochloramine and some excess ammonia in the distribution system. Plants that use excess chlorine may exceed chloride waste water limits.

The OLR regulation involves ability to leave contaminated (fecal) birds for on line trimming and application of some chemical (before the chiller). There are different cabinets and application techniques. Online reprocessing chemicals include: TSP, SMS, acidified sodium chlorite, chlorine dioxide(CLO2), hypochlorous acid(HOCL), peroxyacetic acid(POAA), cetyl pyridinium chloride (CPC), Bromine, and Sterifix (which is a mixture of multiple acids like phosphoric, sulfuric, citric acids.) During the continuous application of these chemicals for the most part there is a steady stream of chemicals going in to the full waste water system. "Slugs" of chemical may be dumped into the system; however timing of chiller emptying and sanitation all combine to dilute the chemicals going into pretreatment.

The Rhodia Company which developed TSP as an online reprocessing antimicrobial chemical now has two chemical options: TSP (trisodium phosphate) and SMS (Sodium Meta Silicate). Different names over the years for TSP are AvGard - Assur Rinse - TSP. A 10-12% solution of TSP is applied in a recirculating rinse cabinet to chicken after evisceration prior to the water chiller. The action of TSP is as a

NEW USES FOR CHICKEN FEATHERS KERATIN FIBER

Walter Schmidt and Justin Barone
USDA / ARS/ ANRI / BARC / EQL
Beltsville, MD 20705
schmidtw@ba.ars.usda.gov
baronej@ba.ars.usda.gov

About 1945, dresses were made from cloth that in turn had been made from chicken feathers through research at the USDA.

Present Uses of Feathers

In the US, feathers are combined with other poultry by-products, cooked and autoclaved, then made into a feather meal for poultry and dairy farms as a feed additive. In the EU, regulation/statutes preclude animal feed options. The first non-traditional commercially available product "Plantables" is a biodegradable seedling starter made from feathers.

Milestones

- Invention Report: Paper from feathers 1993.
- **U.S. patent "Fiber and Fiber Products" 1998.**
- Licenses to Convert the Patent to Practice granted to: Featherfiber Corporation, Maxim LLD, and Tyson Foods 1999.
- **First operational pilot plant, on-line 2002; first operational product line "Plantables," 2003.**
- ARS hired Polymer Scientist Justin Barone October 2002.
- **New Patents Filed, CRADA partner , 2004.**

Feathers to Fiber / Fiber Products

- MAKING FIBER PROCESS
    - Remove non-feather components from feather stream.
    - Wash / sanitize and dry feathers.
    - Disconnect fiber and quill.

- MAKING FIBER PRODUCTS
    - Generate prototype end products.
    - Select end users of Fiber in specific end product markets to actually make end product
    - Option: Have end user select end product before prototype is made.

AIR FILTERS

The large amount of macroscopic free volume in a bundle of bulk fibers can be used to capture dust and particulates so this fiber can be made into air filters.

FIBER REINFORCED PLASTIC

High strength, stiff, and low-weight composite materials can be made using keratin feather fiber with synthetic commodity or natural polymers.

CONSTRUCTION MATERIALS

Composite (cellulose based) construction material: too heavy; insufficiently strong.

Keratin (protein) construction material: comparable in strength less dense and stronger. Keratin is indigestable to termites.

KERATIN FILMS AND COATING

Keratin can be made into clear films and coatings without adding synthetic polymers.

Potential end use: biodegradable agricultural film to control weed. Presently used plastic films must be physically removed at the end of the growing season and transported to a recycling center. Keratin films contain no unnatural products and since they are biodegradable, they can simply be tilled into the soil.

SUMMARY

The low bulk density of keratin feather fiber agglomerates can be exploited to make high quality filters and effective insulation material. High strength, stiff, and low-weight composite materials can be made using keratin feather fiber with commodity polymers. Keratin from feathers can be made into keratin films and coatings without inclusion of synthetic polymers.

CONCLUSION

End user are probably best at deciding which product to make and the properties required of that product. ARS scientists, through CRADA and licensing agreements, assist end users in formulating specific desired properties into a given end product at a given cost to make. Market forces determine which end products are viable and /or commercially successful.

ECONOMICS OF FAT CONSUMPTION FOR FUEL

David Winsness
CEO
Vortex Dehydration Technology
7509 Connelley Drive, Suite E
Hanover, MD 21146

Ph: (410)553-8010; Fax: (410)553-8002
winsness@vortexdehydration.com; www.vortexdehydration.com

Introduction

Vortex Dehydration Technology (VDT) is focused on developing state of the art technologies that are used in several industries. The industries we work in include (but not limited to): Power Generation, Food Processing, Ethanol Production, Bio-Diesel Production, and Plasma Gasification. Through these associations and technological developments, VDT has a solid understanding of the effectiveness of Animal Fat when used as Fuel.

This presentation will review the following:

- **"Current Animal Fat Markets"** and respective profitability

  These include:

  1. Edible Food Production
  2. Pet Food
  3. Commercial Feed
  4. Energy

- **"Competitive Oils"** that are being introduced into the market which may displace or compete with animal fats

  Significant Volumes of Inedible Commercial Grade Vegetable Oil may be injected into the feed market, which would likely displace animal fats.

- **"New Fuel Developments"**, primarily Animal Fat Fuels

  There are three uses for Animal Fat Fuels. They include Fuel Stock (i.e., boiler fuel), Bio-Diesel, and Gaseous Energy Conversion through Disassociation of Particles. We shall address the market limitations and economics of each.

AIR QUALITY AND EMISSIONS REGULATIONS

Ray Knighton
USDA-CSREES
800 9th Street SW
Room 3186 Waterfront Center
Washington, D.C.

Ph: 202-401-6417; Fax: 202-401-1706
rknighton@csrees.usda.gov

No Paper Submitted

TECHNOLOGY FOR MEASURING EMISSIONS: LIMITATIONS/BENEFITS

Richard S. Gates
Professor and Chair
Biosystems and Agricultural Engineering Department
128 C.E. Barnhart Building
University of Kentucky
Lexington KY 40546-0276
USA

Ph: (859) 257-3000 x 128; Fax: (859) 257-5671
rgates@uky.edu; www.bae.uky.edu/gates

Summary

A method is presented for measuring emissions of ammonia that has been successfully employed for our multi-state, multi-disciplinary research project. Other emissions, including dust, can also be measured using this basic approach. Since emission rate is the product of pollutant concentration and exhaust air flow rate, both quantities need to be accurately determined. Our team has developed an innovative, low-cost and accurate methodology which allows multiple buildings to be sampled.

Determining ventilation rate at any time is not a trivial task. We have implemented two methods for ventilation measurement: directly, and using a CO_2 balance. Direct measurement is used in broiler houses and in some layer operations, whereas a CO_2 balance is used on layer buildings. Other methods, such as multiplying the number of fans by a nominal flow per fan, can be grossly inaccurate since the significant effect of building static pressure is neglected, and it does not account for mechanical condition and degree of maintenance both of which can significantly affect actual fan capacity. For direct building ventilation measurement, we use the Fan Assessment Numeration System (FANS) device (Gates et al., 2004).

Twenty-eight portable monitoring units (PMU) were fabricated and used for field acquisition of exhaust NH_3 and carbon dioxide (CO_2) concentration, and building static pressure. Ammonia is measured with redundant electrochemical sensors that are cyclically purged to eliminate errors caused by saturation from continuous exposure to NH_3-laden air (Xin et al., 2002). The redundant NH_3 unit minimizes missing data due to sensor failure.

An overview of the limitations and benefits of the ER measurement system is presented.

Description of the Problem

To obtain poultry building emission rates (ER), one needs to know the concentration of the aerial pollutant under concern at the source and the corresponding air exchange rate through the source. Past experiences have repeatedly shown that it is a formidable task to reliably quantify either of the two variables, on a continuous and extended basis, for CAFO applications. The challenge associated with the concentration measurement stems from the harsh nature of the sample air that analytical instruments are of all sources on that farm, is 100 lbs/day for both NH_3 and H_2S; under the CAA, the annual limit of any regulated compound is 25 tons/year in regions that have attained acceptable air quality.

With the emerging pressure to further regulate agriculture, consent agreements between animal and poultry industries, and the US EPA (Environmental Protection Agency), have been proposed to allow time for emissions study and mitigation within animal agriculture while protecting participants against possible federal lawsuit for past and current violations. At the time of this writing, there is no clear indication that the meat-bird or dairy industries will join this effort; egg producers and the swine industry have elected to participate, although this has not been finalized.

For a 30,000 bird broiler house, daily emissions over1.5 g/bird will exceed the CERCLA threshold of 100 lb NH_3/day. For a 100,000 bird layer house, daily NH_3 emissions over 0.45 g/bird will exceed the threshold. Our preliminary findings suggest that broilers raised on built-up litter may be over limit during later growth stages when birds are near market weight. High-rise layer houses will likely be over limit most days of the year while manure belt layer houses will be under limit. This latter evaluation does not include NH_3 emission from the manure storage associated with manure belt houses.

Development of the Portable Monitoring Unit (PMU)

Evaluation and Selection of Ammonia Monitors

Past experiences of the authors and other researchers (Wilhelm, 1999) suggested that when properly calibrated and operated, electro-chemical (EC) sensors provide reasonable measurement of ammonia (NH_3) concentration. It was also our expectation that recent advancement of technology has led to further improved quality of the products. EC monitors are much more affordable and portable as compared with analyzers employing infrared, thermal oxidation, or open-path optical technologies (McCulloch and Shendrikai, 2000; Harris et al., 2001). In principal, at least, use of EC sensors allows collecting data on a fixed budget to be taken from a greater number of poultry houses than can be done with a more expensive and less portable methods. This led to our decision to evaluate the EC-NH_3 monitors. A complete description of the methodology and results of these evaluations are given in Xin et al. (2002). After this evaluation, which included static repeatability, transient response, drift characteristics, and ability to withstand saturation by regular periodic purging, we selected for use the Pac III H with a 0-200 ppm sensor and a H_2S filter from Dräeger Safety, Inc. (GDS Houston Office, Houston, Texas). The Pac III H has a resolution of 1 ppm, and an internal data storage capacity of 7,200 points. An optional kit (with GasVision software, download module cable, and 120 V power adapter) is used in conjunction with the Pac III H for the logger programming and data retrieval.

EC sensors have an inherent characteristic of saturation when continuously exposed to NH_3-laden air. Once saturated their measurement is invalid. As such, these units are designed for background ammonia monitoring, where normally no NH_3 exists in the environment (Rich Wanek and Victor Hoang, Draeger Safety Inc., personal communication, 2001). For the monitors to be used in continuous monitoring of NH_3 in CAFO settings, the sensors must be periodically rejuvenated.

To rejuvenate the sensors, zero gas must be regularly introduced to the units and we refer to this action as "purging". After an evaluation of the time requirements for purging and sampling, a 48 h evaluation of the Pac III unit was performed to further quantify the responses of the sensor to sampling-purging cycles. The choice of 48 h period was based on the intended measurement duration per monitoring event in the

Operation of the Portable Monitoring Unit

Before each field use, all Pac III units are checked for calibration and programmed to collect data at 30 or 60 s intervals. The CO_2 monitors are checked against the zero and span calibration gases, and calibrated if necessary. The data logger for the CO_2 monitor output and the timer switching measurement is also programmed to collect data at the same interval and with a delayed start of specified date and time. The units are turned on upon arrival at the field site. At the end of each 3-d monitoring episode, the instruments are brought back to the campus lab, data are downloaded, sensors are checked and calibrated or replaced as needed. The units are then cleaned and disinfected to the extent possible without adversely affecting the integrity of the sensors before they are sent to another field site.

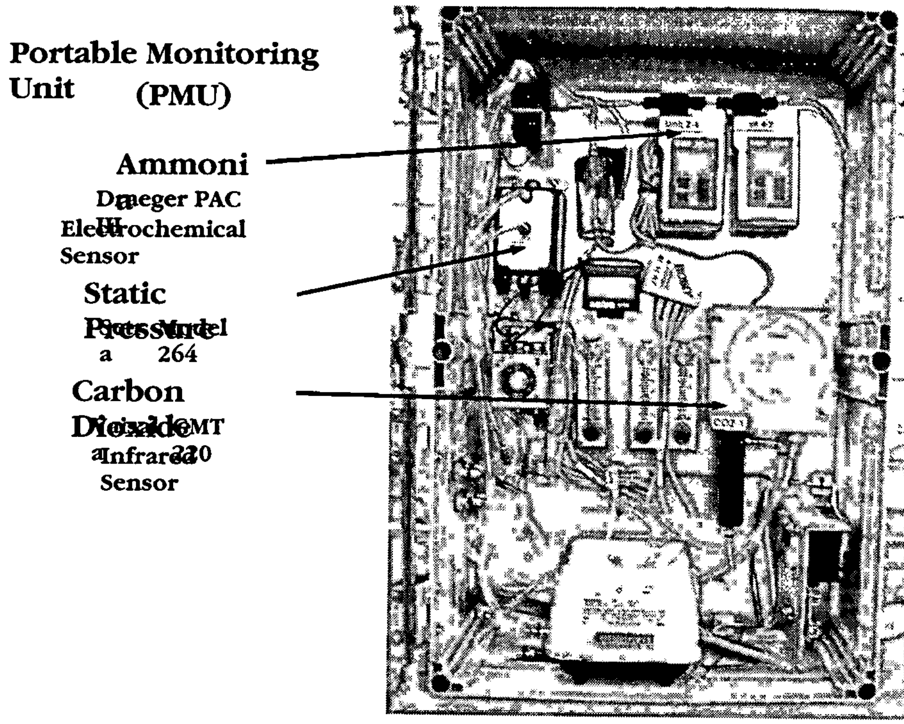

Figure 2: Photograph of the PMU units as used by the UK research team.

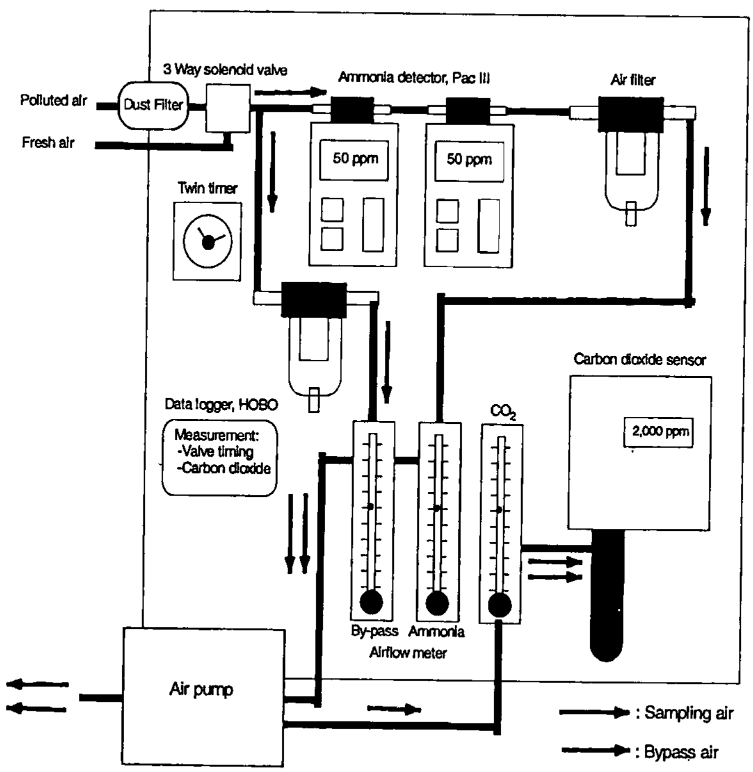

Figure 3: Schematic of the PMU unit (from Xin et al., 2002).

rate was approximately 120,000 cfm, whereas it would have been assumed to be either 138,000 or 141,000 cfm for the industry-used rule of thumb, or the BESS lab data, respectively. Building ER would then be overestimated by this proportion (i.e. 15% or 17.5%, respectively).

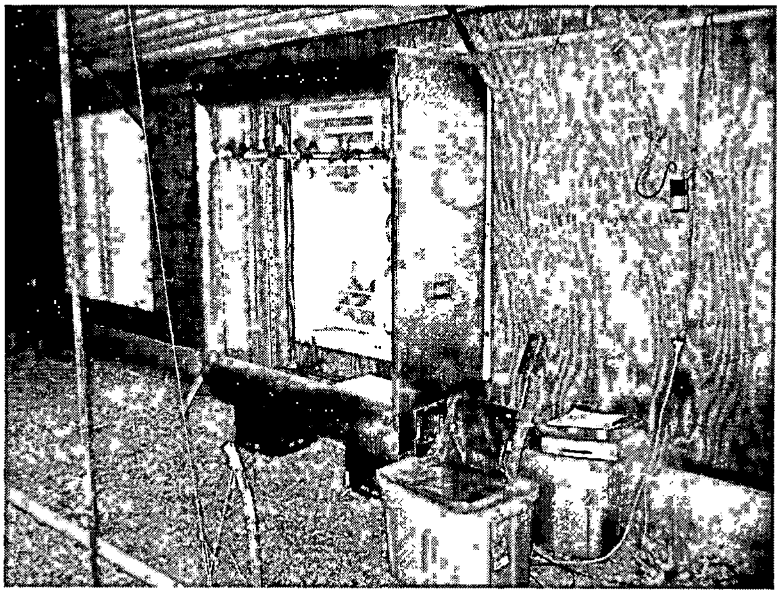

Figure 4: The FANS deployed in a broiler house. The five anemometers traverse the flow field, acquiring approximately 1.8M data points in about 180 s. The average velocity is multiplied by the effective cross sectional area to obtain the mean ventilation rate. The system is controlled by the laptop computer in the foreground.

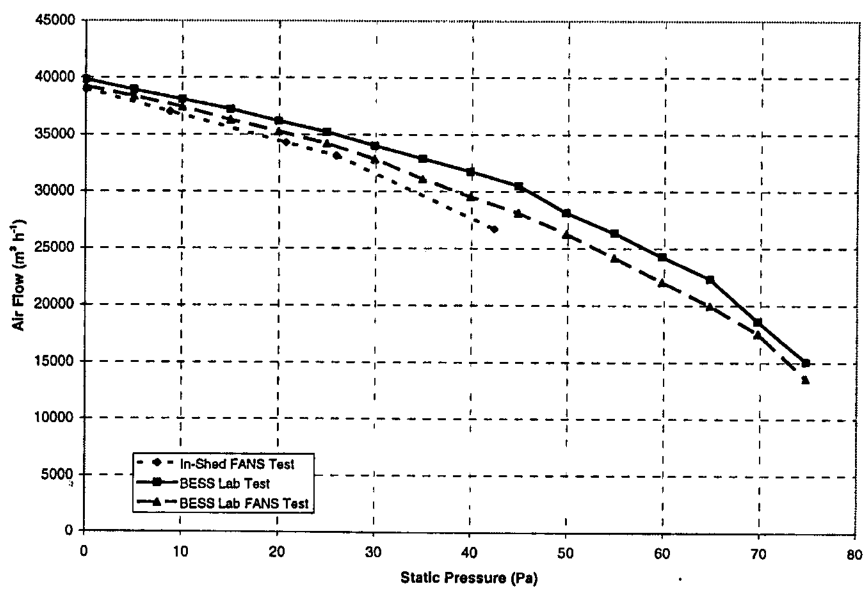

Figure 5: Fan performance curve (airflow vs. static pressure across the fan) for a 48" fan used in a KY broiler house. The three curves represent a certified rating from the BESS Labs at University of Illinois (top curve); the same model fan measured by the FANS unit at the BESS lab; and the same fan measured in-situ in the broiler house.

Indirect Determination of the Building VR by CO_2 Balance

This method is described in detail in Li et al., (2004). The indirect determination of ventilation rate was used for layer operations. Data were collected for broiler houses to assess the degree of inaccuracy associated with respiring litter (which is not present in layer facilities).

Combining PMU and VR Measures to Obtain Emissions Rate (ER)

Final data quality analysis/quality control is underway for the three Universities involved in the poultry ammonia emissions project. Interim reports and conference papers are available on our web site at: www.bae.uky.edu/IFAFS . Baseline data, and effects of management practices, are provided.

Summary

A low-cost, rugged and reliable system for determining ammonia emission rate from poultry facilities has been used for the past 2.5 years in more than two dozen broiler and layer houses in three states. The system is composed of a portable monitoring unit (PMU) for gas concentrations and building static pressure, fan motor loggers and determines building ventilation rate from either direct measurement using in-situ fan performance curves, motor loggers and measured static pressure, or indirectly from a CO_2 balance. This method allows for many buildings to be monitored as opposed to other systems in which only one or two houses can be monitored. The direct measurement of fan performance curves, followed by continual monitoring of fan activity and building static pressure, is a critical component of this measurement system for broiler housing; a CO_2 balance method for ventilation rate is necessary for layer houses.

Limitations

Several limitations are evident in any approach to measuring building emissions rate. First the instrumentation for concentration must be reliable and regularly calibrated. Second, direct determination of building ventilation rate, which can vary continuously, requires either careful field calibration of each fan in a building or perhaps a representative sampling of fans; and continuous measurement of building static pressure and motor run-time for each fan. For indirect ventilation rate, CO2 and heat production equations are used to estimate building ventilation.

Benefits

Development of baseline emissions data for US Poultry operations is a necessary first step for the industry to comply with existing regulations on reporting emissions. The method developed by our team, as reported here, is capable of testing management techniques to control ammonia emissions, such as litter amendments, frequency of litter cleanout, minimum ventilation rates, and dietary manipulation.

ACKNOWLEDGEMENTS

Financial support to this study was contributed by the USDA-IFAFS program, the Agricultural Experiment Stations of Kentucky, Iowa and Pennsylvania, the 6-state Animal Waste Management Consortium, Iowa Egg Council, and Multi-State project S-291.

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AIR QUALITY FROM LAYERS, TURKEYS AND BROILERS

E.F. Wheeler, H. Xin, R.S. Gates, Y. Liang, K.D. Casey, J.L. Zajaczkowski, P.A. Topper*

Eileen Wheeler
Associate Professor
228 Agricultural Engineering Building
Agricultural & Biological Engineering
The Pennsylvania State University
University Park, PA 16802
814-865-3552 efw2@psu.edu

Introduction

Although the federal Clean Air Act has not typically been enforced within animal agriculture, the act did not specifically exempt agriculture or animal CAFOs (concentrated animal feeding operations). Lawsuits have challenged agriculture to comply with standards set as part of the Clean Air Act. Specifically, CAFOs are asked to comply with CERCLA and EPCRA regulations. CERCLA is Comprehensive Environmental Response, Compensation and Liability Act and covers ammonia and hydrogen sulfide emissions that will be of interest to animal agriculture (CERCLA and these other acts regulate additional emission compounds that are of primary interest to other industries) EPCRA is Emergency Planning and Community Right-to-Know Act that monitors ammonia and hydrogen sulfide. The Clean Air Act (CCA) also requires monitoring of VOC (volatile organic compounds), PM_{10} (fine particulate matter less than 10 microns in diameter), NO_x (various nitrogen-oxygen compounds), and H_2S (hydrogen sulfide). EPA has a web site with information targeted at agricultural issues: www.epa.gov/agriculture, with this page going to the National Agriculture Compliance Assistance Center.

With the emerging pressure to regulate agriculture under these laws, consent agreements with US EPA (Environmental Protection Agency) are being proposed to allow time for emissions study and mitigation within animal agriculture while protecting participants against federal lawsuit for past and current violations. There have been very limited data available for making decisions regarding poultry housing and manure handling practices that reduce gas and particulate emissions. In fact, there is very limited data to even document the level of current emissions from US animal agriculture.

For poultry housing the primary concern will be with ammonia emissions. Particulates (dust) may be of concern for layer houses. Hydrogen sulfide will be an unlikely regulatory issue for poultry farms (will be of concern to swine industry). Essentially, if a farm site is over EPA limits on any of the compounds regulated by the CCA, CERCLA or EPCRA, then a permit will be needed and emissions over the limit are required to be reported.

Regulatory limits for each farm, which is the sum of all poultry houses on that farm:

Particulates (PM_{10})	110 ton/year
Ammonia (NH_3)	100 lbs/day
Hydrogen sulfide (H_2S)	100 lbs/day

Ammonia is created during the chemical and microbial breakdown of uric acid after excretion from the bird. Lower pH, lower temperature, and lower manure moisture content each reduce ammonia volatilization so manure management is key to reducing ammonia emissions.

For a 30,000 bird broiler house daily emissions over 1.5 g/bird will provide greater than the CERCLA 100 lb NH_3/day. For a 100,000 birds layer house daily ammonia emissions over 0.45 g/bird will be over the CERCLA limit. Recent study findings from poultry housing suggest that broilers raised on built-up litter may be over limit during later growth stages when birds are near market weight [Casey et al. 2004 contains 4-flocks' data from 4 houses. The entire study evaluated 5 or 6 flocks in each of 8 broiler houses (44 flocks of data total)]. High-rise layer houses will likely be over limit most days of the year while manure belt layer houses will be under limit. This latter evaluation does not include ammonia emission from the manure storage associated with manure belt houses. (Liang et al., 2003 and Xin et al., 2004 present data from a study of 6 Iowa layer houses, both high-rise and manure belt design.) Figures 1 to 4 show ammonia concentration and emissions from four commercial layer houses. A key component of reducing ammonia emissions will be manure handling. The high-rise houses suffer high ammonia emissions due to the large quantities of manure stored with the birds.

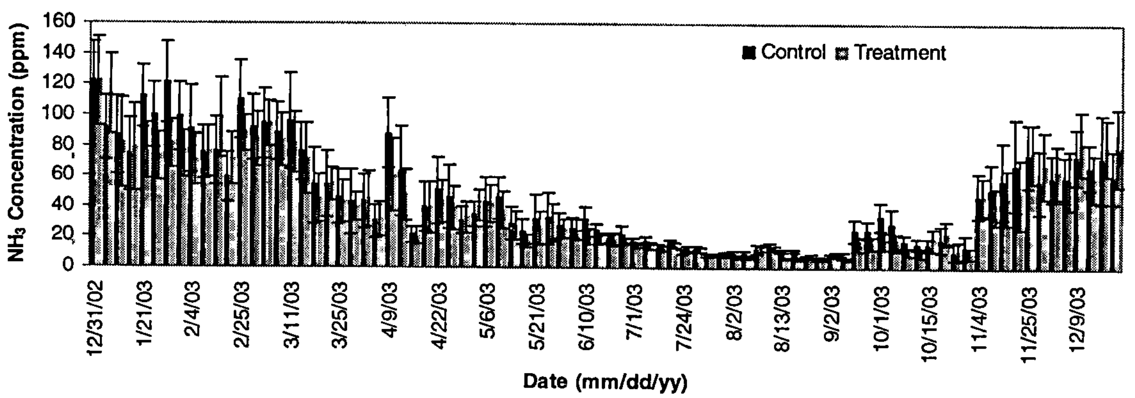

Figure 1. Ammonia concentration at fan exhaust in four high-rise layer houses in Iowa with standard (Control) or low protein (Treatment) diet. Each bar represents a 24-hour average of ammonia data collected every 30 minutes with narrow vertical lines as standard deviations. (Xin et al. 2004)

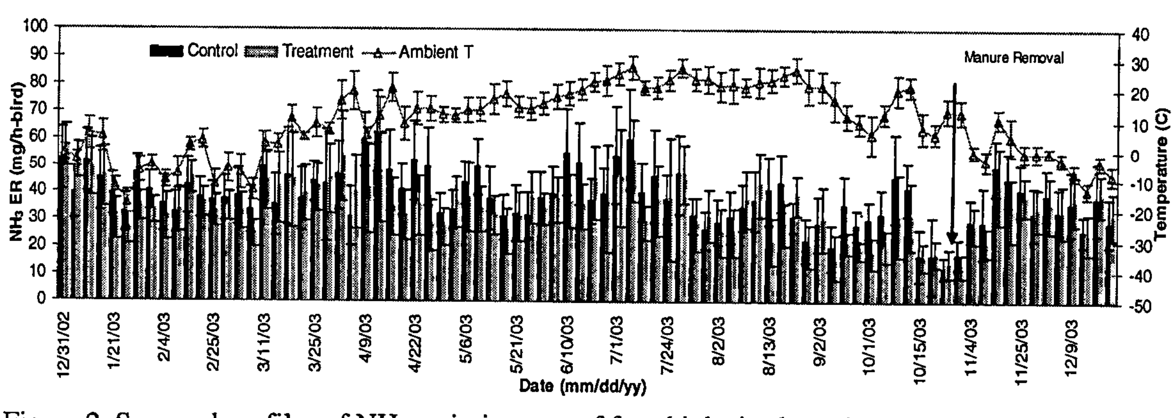

Figure 2. Seasonal profiles of NH_3 emission rate of four high-rise layer houses in Iowa; ambient outdoor

Hydrogen Sulfide

Field data indicate that low levels of H_2S are produced in high-rise layer and litter-raised broiler houses (Similar conclusion expected for manure belt layer houses.). Data from an Indiana high rise house H_2S emission rate ranged from 2 to 7 mg/s for the whole house (Lim, Heber and Ni, 2003). The average emission of 4.3 mg/s was equivalent to 372 g/day or 0.82 lb H_2S/day, which is well under the 100 lb/day CERCLA limit. Broiler house data were available from one Minnesota facility where H_2S emissions were recorded at 0.29 to 1.07 mg/s for the whole 50,000 bird house (Wood et al., 2001) equivalent to 25 to 92 g/day or 0.05 to 0.20 lb H_2S/day.

Summary

Future Clean Air Act regulation of poultry farm gas and particulate emissions will strive to improve national air and water quality. The objective of CERCLA is to clean up uncontrolled releases of specific hazardous substances, ammonia and hydrogen sulfide, in the case of the poultry industry. It appears from recent data that many poultry farms will be outside the acceptable limits for ammonia emissions but well within limits for hydrogen sulfide emissions. Emissions reduction strategies will challenge the poultry industry to change production house and manure management.

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*Author Affiliations from Title Page

Eileen Fabian Wheeler[1], Associate Professor

Hongwei Xin[2], Professor

Richard S. Gates[3], Professor and Chair

WHAT CAN BE DONE TO LOWER EMISSIONS FROM BROILER FACILITIES?

Anthony J. Pescatore
Department of Animal Sciences
University of Kentucky
604 Garrigus Building
Lexington, KY 40546-0215

Ph. 859-257-7529; Fax: 859-323-1027
Apescato@uky.edu

Ammonia emissions from commercial broiler houses are a growing concern in the United States. There are increased concerns that regulations through the federal Clean Air Act (CAA), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Emergency Planning and Community Right to Know Act (EPCRA) will be applied to animal agriculture. Under CAA, the amount of ammonia emissions that would trigger additional regulations is 100 tons/year. The reporting requirements for ammonia releases under CERCLA and EPCRA have a base of 100 pounds/day. The potential of this federal regulation being applied to poultry operations has created a need for additional information on air emissions. The need for baseline data concerning ammonia emissions has resulted in numerous studies in broiler houses. The results are variable due to the methods of gas analysis, location for air sampling, as well as differences in bird and litter management. A review of the available information concerning broiler houses indicates the following trends: ammonia emissions are greater in summer than winter, and a single broiler house will rarely exceed 100 pounds/day. However, multiple houses on a site can exceed the 100 pounds/day threshold (Gates et al., 2004). If multiple houses will be grouped together in regards to regulations, strategies for reducing ammonia emissions will need to be developed. The potential strategies include litter management, feeding program, litter additives and ventilation programs.

Litter Management

Nahm (2003) indicates that the order of importance of factors that influence ammonia formation is litter pH > temperature > moisture content. In that study, total fixation of nitrogen occurred below pH 4; lower temperatures (<10°C) were needed to influence volatilization; and moisture content influenced the microbial activity that is important to volatilization. The frequency that litter is changed or that cleanout occurred and the potential dryness of the new litter and the reduction in nutrients will impact ammonia emissions. Gates et al. (2004) indicated that ammonia emissions were lower on a farm that had new litter for each flock when compared with a farm having built-up litter.

Feeding Programs

The level of protein in the diet can influence the amount of nitrogen in the litter. Most diets contain excess nitrogen as a safety margin. By formulating diets on an amino acid basis, the total protein level of the diet can be reduced. Ferguson et al. (1998) indicated that for each one percent decrease in protein there was a seven percent decrease in ammonia. Dietary manipulation has potential for reducing ammonia; however, the diets must be reformulated to account for potential impacts on performance.

AIR QUALITY AND EMISSIONS: NEW ALTERNATIVES FOR PULLET AND LAYER HOUSES

Paul H. Patterson
Department of Poultry Science
213 Henning Bldg.
The Pennsylvania State University
University Park, PA 16802-3501

INTRODUCTION

A portion of this paper herein was derived from a previous presentation at the 2004 Poultry Science Association Symposium on Air Emissions and Poultry Production (Patterson and Adrizal, 2004). Air emissions from poultry production are numerous and may include ammonia, odor, dust or particulate matter (PM), and other gases (Wathes et al. 1997; Takai et al. 1998). Ammonia emissions can be significant. Our own data gathered using mass balance techniques with commercial pullets and laying hens (Table 1) indicates that between 31 to 40% of feed nitrogen is lost to the atmosphere mostly as ammonia-N (Patterson and Lorenz, 1996, 1997). Ammonia emissions have the potential for both wet and dry deposition and contamination of surface and ground waters (Paerl, 1995, 2002; Paerl et al., 2002). The US EPA estimates 64-71% of ammonia emissions are from livestock and poultry production (Powers, 2002). And in the Chesapeake Bay air-shed current estimates indicate that poultry and livestock contribute 81% of the annual NHx atmospheric burden (Seifert et al., 2004). Nitrogen and sulfur oxide compounds (NO_X SO_X) – nitric oxide, nitrous oxide etc. can be converted to nitric and sulfuric acid and are factors in acid rain formation (Powers, 2002).

The NRC (2003) National Academy of Science ad hoc committee on air emissions from animal feeding operations (AFO) recently summarized their concerns listing key air pollutants and their relative importance with respect to air quality in different geospacial scales (Table 2). The primary air pollutant of concern on a global, national and regional scale is ammonia because of atmospheric deposition and haze. On a local scale, ammonia generated by AFO's is a minor concern because it is a colorless, odorless gas at low concentrations encountered outside confinement poultry housing. However, a major concern at the local level is odor because of its implications for quality of life for people in the immediate area. Another significant concern is also placed on H_2S at the local level because it is often a component of odor and PM2.5 and PM10 because of health and haze considerations. PM2.5 and PM10 are airborne particulate matter or dust less than 2.5 and 10 microns in size. They can result from combustion processes, but secondarily when ammonia SOx and NOx react in the atmosphere forming ammonium sulfate and nitrate they contribute as much as half of the PM2.5. Although odor and H_2S can be significant concerns at the local level they may not be a dominant concern with poultry compared to other livestock species, as they do not have the impact on human health and haze as do dust and PM. In June 2004, US EPA sent letters to state authorities showing additional non-attainment counties not meeting the PM2.5 air quality standard. These will be the basis of their final designations in November (USEPA, 2004).

The negative impacts of air contaminants on poultry health and performance have been well documented. Ammonia at various concentrations has been reported to result in keratoconjunctivitis (Bullis et al., 1950) and greater circulating WBC and lymphocytic infiltration of the eye (Patterson et al., 2000) increase susceptibility to airsac (Kling and Quarles, 1972) and Newcastle disease (Anderson et al., 1964), reduced ppm) and dust (15 mg/m^3) are too high, recommending lower exposure limits for these combined substances at levels of 7 ppm and 2.5 mg/m^3, respectively.

MANAGEMENT STRATEGIES FOR REDUCING EMISSIONS

Reducing airborne contaminants and their release requires several approaches to reduce generation, reduce their emission, and finally enhance their dispersion. Effective control usually relies on more than one strategy beginning in the poultry house, manure storage and on to land application. On a local scale enhancing dispersion can be an effective means of reducing the impact of H_2S, PM2.5, PM10 and odor on neighbors and others negatively affected by their close proximity. Utilizing site planning, weather dispersion and setback distances are effective means of allowing natural dilution of odor, dust and gases. These same principles can be applied to ammonia and other airborne contaminants although their negative impacts are on a regional, national or global scale requiring preemptive strategies focusing on reducing their generation and emission.

The metabolic end product of protein and nitrogen metabolism in the domestic fowl is uric acid. Typical excreta contains 13 to 17g/kg total-N on a DM basis, with 60 to 75% uric acid-N, 0 to 3% urea-N, 0 to 3% ammonium-N, and 25 to 34% undigested protein-N (Groot Koerkamp, 1994). Microorganisms mediate the breakdown of uric acid and protein. The enzyme uricase is commonly present in microorganisms and specific to this reaction. It is the first step in the break down of uric acid hydrolyzing it to allantoin. The breakdown of uric acid is influenced by temperature, pH, water activity and moisture content. This understanding is paramount to implementing manure and other management strategies for reducing ammonia losses.

Dietary Strategies to Reduce Emissions

There are numerous dietary strategies for poultry aimed at reducing the generation and emission of ammonia and other nutrients in the production setting (Elwinger and Svensson, 1996; Patterson, 2001; Burnham, 2004). For dust and particulates, experience has indicated adding dietary fat can reduce the feed dust in the animal's environment. And although they are important first lines of action that can significantly reduce air emissions, they are not the focus of this review. Management techniques aimed at reducing or capturing air contaminants generated in pullet and egg production are numerous but vary in cost, effectiveness and practicality. For the reasons stated above we will be addressing management strategies aimed at reducing emissions.

Reduce Stress and Maintain Bird Health

Bird health and status of the gastrointestinal tract are critical for proper nutrient retention. Stressors include temperature-humidity stress with either improper brooding conditions or equipment and improper ventilation resulting in both cold and heat stress. Exposure to viral, bacterial and other agents can challenge birds resulting in watery droppings, diarrhea and poor feed conversion. Healthy birds maintained in a thermoneutral environment are better able to utilize dietary nutrients to their fullest potential, and minimize shedding of dietary and endogenous nitrogen and moisture. Lastly, bird density and crowding can magnify other stressors leading to poorer nutrient utilization.

House Cleaning

Other simple techniques of reducing dust emissions from poultry buildings are regular house cleaning including vacuuming and power washing between production cycles thereby reducing the volume and

Manure Management

Simple manure management procedures can greatly influence dust levels and the loss of ammonia. Hens on litter with less than 25% moisture can generate dusty conditions. Conversely, manure moisture contamination or excessively wet feces from dietary ingredients are factors leading to ammonia volatilization. Drinker type and management including maintenance for leaks and height adjustment can both impact manure moisture. Exogenous water contamination of manure must be controlled from rain, surface and ground water sources. Lastly, proper ventilation in all seasons will exhaust bird moisture on a daily basis minimizing moisture accumulation in the manure.

Manure Amendments

An important tool in modern broiler management is the use of litter amendments to trap and hold litter nitrogen using one of several techniques including adsorption, acidification, or salts to influence microbial populations and enzyme activities. Although not utilized to their fullest extent with pullets and laying hens, Reece et al. 1979, Terzich, 1996 and Moore et al. 1996 demonstrated the ability of several compounds including sodium bisulfate, ferric chloride, ferrous sulfate, phosphoric acid, superphosphate and aluminum sulfate to reduce ammonia volatilization. Wilson in 2002 reported on the application of liquid alum in the pit of a commercial high-rise hen house utilizing RainBird® irrigation nozzles to spray 10 seconds every hour. Ammonia levels at bird height were reduced from 70 to 40 ppm within 20 min of the first application and with additional time ammonia levels continued to fall in a stair-step fashion to approximately 20 ppm by 3 hours. Other amendments with nitrifying bacteria have the potential to reduce manure NH_3 and NH_4^+ levels as bacteria convert them to nitrite and nitrate NO_2^- and NO_3^-, respectively (Kim and Patterson, 2004b).

Work by Kim and Patterson, 2003a demonstrated that $ZnSO_4$, $CuSO_4$, $MgSO_4$ and $MnCl_2$ can reduce microbial uricase activity. $ZnSO_4$ was also effective in reducing manure pH and the growth of uric acid utilizing bacteria. And when added to fresh manure $ZnSO_4$ reduced ammonia volatilization and increased uric acid-N and total-N retention in the samples. Dietary supplementation of Zn can also reduce ammonia losses in hens (Kim and Patterson, 2004c) and increase manure uric acid-N and total-N retention in broiler manure (Kim and Patterson, 2004a). Although trace mineral supplementation to these dietary levels has little practical potential, it does demonstrate the impact of controlling microbial breakdown of uric acid and urea on manure nitrogen and ammonia losses.

Other novel strategies we may see in the future include immunizing birds with the urease enzyme. Pimentel and Cook, (1988) immunized Leghorn and broiler breeder hens with jackbean urease enzyme. Then hens developed antibodies to the enzyme and passed them on as maternal antibodies to their chicks thereby reducing the harmful effects of ammonia in the GI tract by preventing urea hydrolysis to ammonia by intestinal bacteria in the birds. Kim and Patterson (2003b) recently showed it was possible to immunize hens with microbial uricase and produce a high level of uricase-specific antibodies. These egg yolk antibodies IgY have the potential to be fed as a dietary supplement or manure amendment to reduce the breakdown of uric acid to urea.

Composting

Ammonia emissions during manure composting can be significant increasing environmental pollution and reducing its fertilizer potential. However, composting at the right moisture, carbon:nitrogen ratio and temperature with proper aeration can reduce ammonia losses and retain fertilizer value (Hansen et al., 1989; Carr, 1994) . Properly done, composting can bring manure to a stable endpoint for over winter storage and reduce ammonia losses to the atmosphere. Composting amendments including zeolites, calcium and aluminum salts and acidifiers have been shown to improved nitrogen retention and reduced ammonia volatilization compared to control samples of manure (Kithome et al., 1999).

swine building exhaust air. While I am not aware of any poultry examples using water filters, they may have application once their economic and technical practicality are demonstrated.

Ozonation

Ozone O_3 is a powerful oxidizing agent and a natural germicide. Ozone in the upper atmosphere protects the earth from harmful solar radiation; however, it is also a toxic gas at high levels here on the surface. Researchers have demonstrated its ability to react with other gases reducing odor intensity, ammonia (15-58%) and dust (58%) in swine facilities (Jacobson et al., 2001). Although, not utilized in commercial practice, we will have to watch for ozone evaluations and applications in the future with poultry.

Vegetative Filter Belts

Strategically planting trees, shrubs and other vegetative materials around poultry houses offers several potential advantages according to Malone & Van Wicklen, (2002). Trees may foster better neighbor relations by filtering dust, feathers, odor and noises from the operation and provide a visual screen from routine activities and public perception of the industry. Potential environmental benefits include reduced ammonia, dust, odors, and surface and groundwater nutrients leaving the farmstead. Furthermore there are possible production benefits for commercial poultry as a windbreak and a source of shade to reduce seasonal temperature extremes and as a filter for airborne pathogens for improved biosecurity. Demonstration sites on the Delmarva Peninsula have shown a 67% reduction in ammonia level and a 50% reduction in dust level down wind of a vegetative filter belt planted on a commercial broiler farm (Malone, 2004). The ability of plant materials to filter, precipitate, adsorb or incorporate airborne ammonia remains to be documented. Although, there are other results in the literature that suggest plants differ in their sensitivity and ability to utilized atmospheric ammonia (Perez-Soba and Van der Eerden, 1993; Fangmeier et al., 1994; Holtan-Harwig and Bockman, 1994; van Hove and Bossen, 1994; Pitcairn et al., 1998; Van der Eerden et al., 1998). Work with vegetative filter belts for poultry farms is ongoing in Delaware, Iowa, and Pennsylvania with a USDA research and outreach project.

SUMMARY

Dust, ammonia and other regulated emissions from commercial pullet and egg production can be significant and a source of health issues and pollution of the atmosphere and surface waters. Greater scrutiny of all emissions from concentrated animal feeding operations is taking place at the urban rural interface and on a regional and global scale by neighbors, special interest groups and regulators. And although there are numerous dietary and management strategies that can reduce emissions, their implementation and success in many instances will depend on economic and regulatory incentives.

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POULTRY BROILER AMMONIA EMISSION FACTOR COMPARISONS

R.T. Burns
Agricultural and Biosystems Engineering Department
3224 NSRIC
Iowa State University
Ames, Iowa 50011

Ph: 515-294-8921; Fax 515-294-4250
rtburns@iastate.edu http://www.abe.iastate.edu/wastemgmt/

Introduction

Poultry broiler ammonia emission factors have been published using several different units. It is important that the circumstances and assumptions used in calculating these factors are understood before valid comparisons between factors can be made. Differences in emission calculation methods and assumptions in regards to emission factor comparison are discussed.

Concerns regarding ammonia emissions (NH_3) from poultry broiler operations have recently increased in the United States. Ammonia emission inventories suggest that poultry and livestock waste are responsible for 50 - 70% of the total NH_3 emissions in the United States (Strader, 2001), with poultry estimated to contribute over 25% of the total animal emissions. In the 2002 report, *Air Emissions from Animal Feeding Operations: Current Knowledge, Future Needs,* the National Research Council identified the need for improved estimates of gaseous ammonia emission factors from animal facilities in the Unites States (NRC, 2002). In response to this need, new research designed to measure or calculate ammonia emissions from US broiler facilities has recently been initiated by several investigators (Burns, et al., 2003, Casey et al., 2003, Wheeler, et al., 2003, Worley, et al., 2002, Xin, et al., 2002). Over the past decade several attempts to accurately quantify NH_3 emissions from enclosed poultry production facilities have been conducted in Western Europe (Asman, 1992, Demmers, 1999, Koerkamp, 1994, 1996, Sneath et al., 1996, Wathes et al., 1997). The ammonia emission inventories developed in the US over the past decade have been based upon poultry emission factors developed in Europe in the 1990's, such as by Battye et al.(1994) and Asman (1992). Ammonia emission factors from Europe may not reflect conditions representative of those in the US. Specifically, US broiler production is almost exclusively conducted in mechanically ventilated houses where poultry litter is retained for a minimum of 6 – 12 months in the production house. In contrast, western European broiler production is frequently conducted in houses where poultry litter is held in-house for only one flock cycle, which is typically 6 weeks in European systems. These differences in management regimes, along with differences in bird variety, growth period, and stocking density, combine to make it unlikely that ammonia emission rates will be similar in both systems. Table 1 shows a listing of poultry broiler ammonia emission factors from various sources in the US and Europe as presented by Armstrong (Armstrong, 2003). When comparing recently published ammonia emission factors from the US with those previously developed in Europe, in many cases western European emission factors appear to be significantly lower than those at US operations.

Further complicating the interpretation of poultry ammonia emission estimates is the wide range of units that they are reported in. Ammonia emissions are found reported in mass NH_3/bird, mass NH_3/500 kg live a per bird or per house basis at different days during the grow-out period, the resulting factors could be very different. Because the bird mass increases during the grow-out, emission factors that were normalized to bird mass on a daily basis would not show the rate of increase with time that factors generated only by total daily ammonia mass would.

In conclusion it is important to understand the broiler production systems that ammonia emission factors were developed in, as well as the assumptions used in developing the factors. In some cases, recent ammonia emission factors developed in US systems are an order of magnitude greater than some emission factors developed in Europe in the 1990's. While much of this difference can be attributed to differences in US and European production systems, care must be taken to ensure that the assumptions used in calculating the factors are similar. When comparing emission factors it must also be noted if the measurements are short-term or long-term and when they were taken during the flock grow-out cycle. Finally care must also be taken when using values listed as per broiler to determine if they represent a broiler space over a year, or a single broiler over one grow-out cycle.

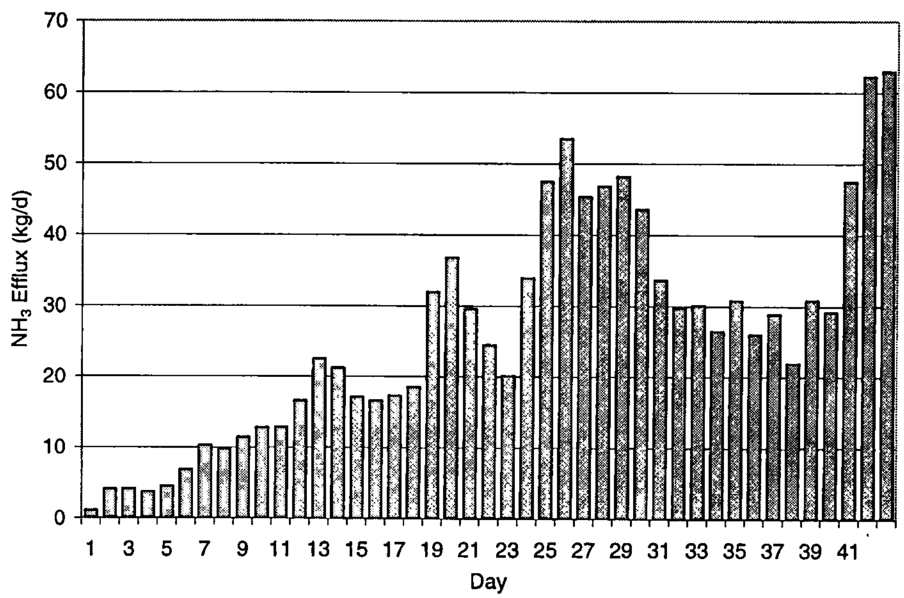

Figure 1 NH_3 emissions vs. time, for flock 6 (mid-winter) – Burns et al, 2002

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COMMUNITIES, ANIMAL AGRICULTURE AND AIR POLLUTION: POLICY ISSUES AND OPTIONS FOR THE FUTURE

Lawrence W. Libby
C. William Swank Professor of Rural-Urban Policy
Ohio State University
2120 Fyffe Road, Columbus, Ohio, 43210

Introduction

The many products of animal agriculture are important to American consumers – of that there can be no question. Effective demand for meat and other animal products increases with income and in fact is often used as an indicator of economic improvement for a population. Livestock production is a visible aspect of farming, and people appreciate farming for the various ways it contributes to the social and economic environment of a place. A recent Ohio survey revealed that 92% of all Ohioans agree that "farming contributes to the quality of life in Ohio," with only 1% disagreeing (Sharp, 2003).

As with most things we value, however, animal agriculture also produces by-products that are distinctly undesirable. The trick is to balance the good with the bad. And typical of many environmental concerns, the problems with animal agriculture tend to be highly concentrated while the benefits are dispersed. Thus opponents of a certain concentrated animal feeding operation may mobilize to object, while the many consumers who enjoy the result of animal agriculture are inadequately motivated to rise in support.

This paper explores the policy issues and options surrounding one set of by-products from one type of animal feeding operation – air pollution from poultry. I come to this topic as a resource economist and rural policy specialist, not as an expert in poultry, animal agriculture or systems engineering. Starting with a brief sketch of the general policy process, I identify the air pollution issues with U.S. poultry production, the policy dimensions and future policy directions.

Economy and Policy – The Basics

All U.S. enterprise, including that related to animal agriculture, exists within a public policy setting. Markets for land, products, and services are really collections of rules that establish the rights and obligations of market participants. Land markets, for example, reflect the rights of land owners as well as the rights of other citizens affected by how land is used. Nobody's rights are absolute, with limits established by the degree to which exercise of those rights impinges on the rights of others. Options available to a poultry producer are limited by the rights of others as defined by the structure of law and policy.

The structure of market rules varies over time and space, reflecting differing knowledge and preferences. Not all preferences are equal, of course, and those with similar attitudes about how a market should function may collectively press their case in the policy arena. The policy process is really about groups of like-minded citizens expressing their preferences for the rules and incentives that they feel should structure market choices. Thus, no market is beyond the reach of policy. The role of government in this mix is to support the results of changes to market rules, and structure the process by which collective preferences may emerge as future rule changes.

just because of air pollution but also various other changes to the quality of rural life associated with the farm size.

Balancing Private and Public Interest

Improving air quality around poultry operations does not necessarily mean more regulations. Producers can make their own changes, and many non-farmers trust farmers to do what is necessary to protect their environment. Fifty-nine percent of respondents to Sharp's Ohio survey believe that farmers will do what is right for air and water quality (2003). Producers have a significant envelope of good will within the general public. They have the opportunity to maintain that positive image and avoid conflict, if they use it.

Sociologists refer to the formal and informal networks of relationships among neighbors in a community or neighborhood as "social capital." The greater the social capital and related mutual trust, the greater is the chance of avoiding conflict that leads to new regulations. If farmers and their neighbors truly understand their mutual needs and preferences there is opportunity for avoiding or resolving conflict. Differences of background and experience need not lead to conflict. Non-farmers need to understand the realities of modern agriculture and farmers must also learn what their non-farm neighbors expect out of life in the exurban area. One study of a changing rural area found that greater frequency of interaction between farmers and non-farmers was associated with fewer concerns about animal agriculture (Sharp and Tucker, 2003).

Comprehensive planning in an area can be a capital-building exercise that helps people see their common stake in the quality of life and how it can be protected (Libby and Sharp, 2003). There are less formal ways to build social capital as well, a pre-emptive approach to farm/non-farm conflict over the quality of rural life. Policy interventions may simply emphasize greater social networking as a strategy for reducing both the air quality problems and the fights about how much pollution is acceptable. Suits over the odor and other pollutants from a livestock or poultry operation can be destructive and costly for all concerned. The permitting process for large scale livestock units has often become a lightning rod for conflict and can seriously deteriorate whatever trust and social connection may have existed.

Location Issues

One obvious way to avoid the human cost of poultry-induced air pollution is by separating the farm from non-farm rural residences. Dispersion of pollutants is a viable strategy. Communities may guide the pattern of development in ways that reduce the incidence of conflict. A few states, notably Nebraska, have stringent local authority for regulating location of animal agriculture (Dahl, 2003). Other states deny townships and other local units the right to control livestock operations or exclude agriculture altogether, but there are ways to encourage farm location in some areas and discourage it in others.

There is plenty of evidence that proximity to large-scale animal agriculture can reduce the market value of a residential property. One of the first such studies found a 9% reduction in home value attributed to a hog facility within ½ mile of the home (Palmquist, Roka and Vukina, 1997). More recently, Ready and Abdalla (2003) found a 6.4% reduction in home value associated with location within .3 miles of a livestock facility in Berks County, Pennsylvania. Research in Iowa demonstrated that a livestock location upwind of homes resulted in an even greater reduction in home value (Herriges, Secchi and Babcock, 2003). So location does matter and is subject to local policy action. It just may be that large scale poultry production is incompatible with many types of housing development in rural areas. While farms are generally a positive aspect of rural aesthetics for non-farmers, large poultry and other livestock operations are exceptions. Land use planning and zoning must take these realities into account.

the neighbors will be part of the producers' accounts. Higher production cost is a necessary aspect of accepting responsibility for the realities of poultry production in rural America.

No one disagrees with the importance of better data for specific types of production systems, but too often demands for measurement precision is a shield to achieve delay or avoid responsibility. Groups on all sides of many issues have used that strategy. The "precautionary principle" fits here as well as in other areas where absolute certainty about impact or source may be illusive. We ask government to protect people from the reasonable possibility of harm. Participation in voluntary self-monitoring of air quality, and providing those data for development of defensible emission standards, is a forthright way to join the issue rather than pretending that it doesn't exist.

Ohio, through the Ohio Livestock Coalition, has two important initiatives to improve relationships with others affected by the by-products of animal agriculture. Other states have similar programs. Livestock producers participate in the Livestock Environmental Assurance Program, improving their understanding of waste and nutrient management needs. And a new brochure directed at producers and their neighbors acknowledges the "It Takes Two to be a Good Neighbor." Too often agriculturalists seem to blame the non-farm neighbor for not understanding farming, without making an effort to understand the neighbor. This program suggests ways to increase social capital in those rural communities.

Provide Incentives for Small Scale Production

It makes little sense to regulate against the economies of size and scale in poultry production. Economic realities do matter in the structure of agriculture and cannot simply be declared illegal. On the other hand, communities or even states that want to encourage small and more diverse farms can certainly do so. Some consumers will pay a premium for product from a small local producer because they prefer the product and want to support local farmers. Signs for "fresh eggs" are common in many small rural towns. Massachusetts has a special bond program for providing assistance to farmers in preparing business plans, seeking new enterprises as the local economy changes, and remaining viable. The 2002 Farm Bill authorizes federal support of state or local farm viability programs. Special incentives may be used to off-set the economic advantages of size.

Other incentives may come in the form of "green payments" for the environmental services provided by small farms that control pollution and provide countryside amenity. The "conservation security program" of the 2002 Farm Bill could be the vehicle for such incentives.

Perhaps air pollution rights could be allocated among livestock producers in an area and a system for trading those rights be established. Air pollution rights are bought and sold among other major industries already and might be extended to large livestock operations. Such systems require considerable data collection and farm level monitoring (Zilberman, Ogishi and Metcalf, 2002).

Regulations

Agriculture has enjoyed special status in major environmental laws (Ruhl, 2000). Many of these exemptions are based on the dispersed nature of farming, the difficulty of attributing environmental damage to specific farms and overall the relatively minor contributions which farms make to large scale environmental issues. Concentrated livestock and poultry production changes much of that, yet agriculturalists understandably try to maintain the exemptions. Maintaining the envelope of good will that farmers have long enjoyed will require more forthright involvement in regulatory programs already imposed on other industries. At least farmers should not expect special treatment if there is a clear cost to the health and well-being of others.

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REGULATING CAFOS IN THE NORTHEASTERN U.S.

Dave Hansen
Assistant Professor of Soil and Environmental Quality
University of Delaware
16684 County Seat Highway
Georgetown, DE 19947

Ph: 302-856-7303; Fax: 302-856-1845
djhansen@udel.edu

INTRODUCTION

Water quality is a critical issue in Northeastern United States. A large number of water bodies, including the Chesapeake Bay have been negatively impacted by nutrient inputs (primarily nitrogen (N) and phosphorus (P). An important source of these nutrients is agriculture; specifically animal operations. The Federal Water Pollution Control Act of 1972 (33 U.S.C. § 1251(a)), more commonly referred to as the Clean Water Act (CWA), outlines the authority of the Environmental Protection Agency to regulate point sources of pollution. This regulation of point sources is accomplished through issuance of National Pollutant Discharge and Elimination System (NPDES) permits; regulation of nonpoint sources is left largely to individual States. Traditionally, point sources were limited to industrial discharges and effluent from sewage treatment plants; entities that have an easily definable conduit to water, while nonpoint sources included logging activities, septic systems, and agricultural operations. However, the CWA (and subsequent amendments) contained provisions to designate animal operations as "concentrated animal feeding operations" (CAFOs) based on the number of animals (or on a case-by-case basis for "bad actors"). The important effect of this designation is that CAFOs are considered point sources and are subject to Federal regulatory authority through the NPDES program.

On January 12, 2001 the Environmental Protection Agency released draft changes to the NPDES program and to Effluent Limitation Guidelines related to the regulation of CAFOs. This draft contained a number of important changes ranging from the definition of a CAFO to various specific permit requirements. Final comment on these draft regulations was due near the end of August, 2002 (after numerous extensions) and the final draft was released in December, 2002 (available online at: http://cfpub.epa.gov/npdes/afo/cafofinalrule.cfm). Most states have delegation from EPA to permit CAFOs through their state regulatory agency (e.g. Department of Natural Resources, Department of Environment, etc.). It is therefore up to individual states to draft state-level regulations consistent with EPA guidelines. The following discussion is focused on five of the larger poultry-producing states in the (vaguely defined) Northeastern US; Delaware, Maryland, Pennsylvania, Virginia, and West Virginia.

A FEW IMPORTANT ISSUES

Identification of CAFOs: Discussion in this paper is targeted toward "large" CAFOs; those which are identified purely on the basis of their size (e.g. 125,000 broilers or 83,000 layers). However, smaller operations can be designated as CAFOs for other reasons including presence in a critical or impaired watershed or environmental violations. Most states have followed the "numerical" criteria listed above for identifying large CAFOs. The exception is Delaware, which has proposed an alternative criterion for population as described in the EPA document (125,000 broilers). Nutrient management plans for CAFOs will be required to follow the guidelines developed in support of the Maryland Water Quality Improvement Act administered by the Department of Agriculture. It is anticipated that approximately 75 operations will be regulated as large CAFOs. Permits will be required by July, 2005. For more information contact Patsy Allen (phone: (410) 537-3625, email: pallen@mde.state.md.us).

Pennsylvania: The CAFO program in Pennsylvania is administered by the Pennsylvania Department of Environmental Protection (DEP). Draft regulations are available for public comment until November 5, 2004. The new CAFO regulations will be in place by December 31, 2006 and will likely apply to a total of more than 450 large operations (both poultry and animal). For more information, contact Cedric Karper (phone: 717-783-7577; email: ckarper@state.pa.us). The Penn State Cooperative Extension has an informative guide to the State regulations online at: http://agenvpolicy.aers.psu.edu/CAFO2003%2014CX.pdf.

Virginia: Poultry operations with more than 20,000 birds have been regulated in Virginia since December, 2000. Draft regulations; the Virginia Pollution Abatement General Permit for Confined Animal Feeding Operations (9 VAC 25-192), were released in May, 2004. The public comment period ended August 13, 2004. Because CAFOs are currently regulated in Virginia, and this action serves only to transfer the regulatory mechanism governing select CAFOs from the VPA regulatory system to the VPDES regulatory system. Large CAFOs are identified by bird population as described in the EPA document (125,000 broilers). Virginia expects that approximately 70 chicken and 30 turkey operations will be regulated as large CAFOs. The program will be fully implemented by February 13, 2006. For more information contact Neil Zahradka (phone: (804) 698-4102, email: nrzahradka@deq.virginia.gov).

West Virginia: Draft regulations were issued for public comment in West Virginia on August 5, 2004. Large CAFOs are identified by bird population as described in the EPA document (125,000 broilers). West Virginia anticipates that approximately 30 facilities will be regulated as large CAFOs. Most operations will be regulated under a general permit that will be required by April 13, 2006. New operations will be required to apply 180 prior to startup. For more information contact Bob Bates (phone: (304) 558-4086, email: bbates@wvdep.org).

SUMMARY

The information included above is a very brief overview of the types of information that will be covered at the Poultry Waste Management Symposium. By the time of the Symposium a number of states will have completed their public comment period and it should be possible to present state-level guidelines in a "near-final" format.

ADDITIONAL INFORMATION

New Federal CAFO Rules: Adapting State Programs to Meet New Requirements is available online at: http://mawaterquality.org/publications/cafo.pdf

CAFO COMPLIANCE
MIDWEST STATE'S PERSPECTIVE

Kevin S. Vinchattle
Chief Executive Officer
Iowa Poultry Association
8515 Douglas Avenue, Suite 9
Urbandale, IA 50322

Ph: 515-727-4701x13; Fax 515-727-4707
Kevin@IowaPoultry.com; http://IowaPoultry.com

Introduction

The US Environmental Protection Agency released a rule in December of 2002 bringing many animal production operations under compliance with the federal Clean Water Act. This rule, commonly referred to as the "CAFO/AFO Rule", places animal operations across the country under similar regulatory requirements. In the past, states have set up their own requirements under a less prescriptive federal system. Under the new federal rule states implementing the federal program must have permits ready to be issued by April 2006. The following information provides a brief glimpse at the current approach of some Midwestern states in meeting the federal requirements.

Illinois

On April 23, 2004 Illinois finalized a new general NPDES permit for all CAFO's to address runoff, the adequacy of manure storage, proper land application and many other matters. The general permit went into effect on May 1, 2004. An owner operator of a "large" or "medium" CAFO, as defined by the regulations, must apply for a CAFO NPDES permit, submit an annual report, and develop and implement a manure and wastewater handling plan (Nutrient Management Plan). Under federal rules, the distinction between large and medium CAFOs is based on the number of animals in the operation, whether manure or wastewater from the operation is discharged to surface water, or if livestock comes into contact with surface water in the areas in which they are confined. Medium size CAFOs may be able to "opt out" of the permit, if they do not have a man-made ditch or pipe carrying manure or wastewater to surface water or have animals in contact with surface water. The IEPA is following the federal EPA deadlines for filing an application for a CAFO NPDES permit.

Minnesota

The MPCA's response to the new federal regulations was to change their general permit to reflect the new EPA requirements and get all of the CAFOs under the permit as soon as possible. Minnesota's rules and regulations were redrawn in 2000 according to draft regulations of the EPA at that time. Therefore, because the final EPA regulations are different than the draft regulations, Minnesota's existing rules and statutes were already adequate to meet the new federal requirements. Only the NPDES permit will be changed to reflect new technical federal requirements. A communication campaign will be undertaken to inform potential CAFOs of changes. Minnesota has held several public meetings which have resulted in

South Dakota

In response to the new federal regulations, South Dakota has incorporated elements of the previously existing general permits and the new federal regulations into one general permit for CAFOs. These changes were enacted September 12, 2003 after a public hearing and became effective October 20, 2003.

Wisconsin

Wisconsin requires every livestock operation with 1,000 animal units or more to obtain a WPDES permit. These permits are designed to ensure that operations choosing to expand to 1,000 animal units or more use proper planning, construction, and manure management to protect water quality from adverse impacts. The Bureau of Watershed Management of the Wisconsin DNR notes that the "no potential to discharge" exemption to NPDES permits will likely be "very difficult to demonstrate."

Iowa

Iowa is updating its regulatory scheme to which, according to the Iowa Department of Natural Resources (IDNR), has regulated animal feeding operations for the last 35 years. Even before the adoption of CAFO/AFO, Iowa regulations contained a "no-discharge" standard for animal feeding operations. The state's regulatory scheme has required construction permits which, in effect, become de-facto operating permits through the imposition of various permit conditions.

In its initial CAFO/AFO proposal IDNR was proposing to add various species numbers together to determine the need for permit coverage. In other words, whereas a 900-head beef cattle and 2,000 feeder swine operation would not require permits for each individual species under the federal requirements, IDNR proposed to require an NPDES permit by combining the two numbers, thus exceeding the 1,000 animal unit threshold. The department has since modified this approach to count multiple species together only if they are managed within the same systems (i.e. confinement or open lot).

The department also proposed amending its definition of "manure" to include "process waste water". Its proposed definition of process wastewater included egg washwater. Egg washwater has long been recognized in Iowa law as not being manure and egg washwater lagoons have been excluded from the definition of manure storage structures. Egg washwater has since been removed from the proposed definition.

IDNR says it will adopt the federal approach relative to the "no potential to discharge" determination. Its proposed rule requires no potential discharge from either production or land application areas under "any circumstances or climatic conditions". Manure and process waste water (i.e. egg washwater) are included in the regulated discharges. Since it is widely accepted the proffer of a negative argument is not possible, it seems it will also be impossible to qualify for this exception under the Iowa approach.

Nitrogen *or* phosphorus may be the limiting factor relative to manure applications. This will depend on Iowa's newly developed "P-Index Rule". Iowa does plan to offer the general permit option although none are developed at this point.

CAFO COMPLIANCE IN THE CENTRAL U.S.

Tim Alsup
Environmental Affairs
Cargill
PO Box 129
Springdale, AR 72764

Ph: 479-756-4830; Fax: 479-751-8945
TimAlsup@Cargill.com

No Paper Submitted

OVERVIEW OF TEXAS COMMISSION ON ENVIRONMENTAL QUALITY GENERAL PERMIT FOR DRY LITTER POULTRY OPERATIONS

Dr. John B. Carey
Assoc. Dept. Head & Extension Program Leader
Poultry Science Department
Texas A&M University
College Station, TX 77843

Phone: 979-845-4318; Fax: 979-845-1921
jcarey@poultry.tamu.edu

The focus of this presentation will be an overview of the essential elements of the general permit that applies to Texas broiler and turkey operations utilizing dry litter waste management systems based on the rule as published on July 27, 2004. Changes in the permit with regards to other poultry operations (lagoon systems) are of a relatively minor nature and will not be discussed extensively.

A. Fees:

Application fee:

If a facility was in existence prior to July 27, 2004, the application fee is $100. The application fee for a new facility is $350.

Annual Water Quality Assessment:

Dry Litter operations are required to pay an annual $300 fee. Other types of operations are required to pay $800 annually.

B. Deadlines:

New construction of dry litter operations (newly defined CAFO's) must take coverage under the general permit or have an individual permit prior to beginning construction.

Existing facilities have until April 13, 2006 to take coverage or get an individual permit.

C. Nutrient Management Plan

A Water Quality Management Plan prepared by the Texas State Soil and Water Conservation Board will serve as the NUP. This plan is based on NRCS Code 590 Practice Standard and has been a requirement for all contract producers for several years.

CAFO COMPLIANCE IN THE WESTERN U.S.

Kevin Clutter
Director of Technical Services
Pacific Egg and Poultry Association
1521 I Street
Sacramento, CA 95814

Ph: 916-441-0801; Fax: 916-446-1063
kclutter@cgfa.org

No Paper Submitted

CNMPS—THE HOWS, THE WHYS, AND THE EXPECTATIONS

Glenn H. Carpenter
National Leader, Animal Husbandry
USDA, Natural Resources Conservation Service
5601 Sunnyside Ave.
Beltsville, MD 20705

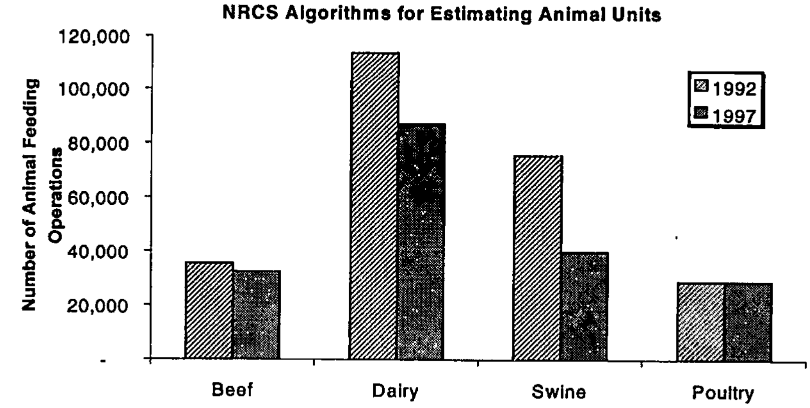
Ph: 301-504-2212; Fax: 301-504-2264
glenn.carpenter@usda.gov

U.S. farmers received $100.3 billion from the sale of livestock and poultry products in 2000, about 52 percent of the value of all agricultural products marketed. America's livestock and poultry production is an important part of both our Nation's economy and its food supply, and the envy of much of the world. However, along with the many benefits that animal agriculture provides, it also produces huge amounts of by-products, such as manure, litter, and wastewater. It is because of these by-products, and their actual and potential impacts to air and water quality, that animal feeding operations (AFOs) have emerged in recent years as a major environmental issue, with significant social and economic considerations.

ENVIRONMENTAL IMPACTS OF ANIMAL AGRICULTURE

The structure of animal agriculture changed dramatically between 1982 and 1997, as the number of livestock operations fell and livestock became more concentrated on fewer operations. Between 1992 and 1997 alone, the number of operations declined by more than 60,000, most notably in the swine and dairy sectors (Figure 1). As the livestock sector has consolidated and concentrated, so manure nutrients have become concentrated in specific regions. Public interest and concern have heightened during the same timeframe. Recent occurrences of nutrient related water quality problems serve to solidify popular opinion as to the need to address the potential environmental risks posed by confined animal feeding operations. Two issues of particular concern are: 1) nonpoint source pollution of waters from improperly managed AFOs, and 2) the inadequacy of traditional land-based manure nutrient management strategies as livestock operations surpass the capacity of the land to assimilate manure nutrients in some geographic areas.

Figure 1: Comparison of 1992 and 1997 Animal Feeding Operations Greater than 25 Animal Units Based on Agricultural Census Data and NRCS Algorithms for Estimating Animal Units



COMPREHENSIVE NUTRIENT MANAGEMENT PLANS

Specifically toward achieving the goal of helping AFO owners and operators to manage their operations in a profitable and environmentally sound manner, NRCS in recent years has identified the environmental needs of AFOs as a top conservation priority - - by focusing the energy and identifying the resources needed to carry out effective information and education of AFO owners and operators, research and technology transfer, direct technical assistance, and financial assistance.

Toward achieving the objective of getting the needed technical guidance in place to help public and private technical specialists assist AFO owners and operators with their development of comprehensive nutrient management plans (CNMPs), NRCS released in December 2000 the Technical Guidance for Developing Comprehensive Nutrient Management Plans. The Technical Guidance provides a framework for helping AFO owners and operators to develop their site-specific, technically sound CNMPs. NRCS' technical handbooks, policies, processes, and planning procedures provide the up-to-date technical references to help fill in the framework.

A CNMP is a subset of a conservation plan that is unique to AFOs. It is a grouping of conservation practices and management activities which, when combined into a system, will help to ensure that both agricultural production and natural resource conservation goals are achieved. The development of a CNMP should address the following six elements:

1. **Manure and Wastewater Handling and Storage** – This element addresses the components and activities associated with the production facility, feedlot, manure and wastewater storage and treatment structures and areas, and any areas or mechanisms used to facilitate transfer of manure and wastewater.

2. **Land Treatment Practices** – This element addresses evaluation and implementation of appropriate conservation practices on sites proposed for land application of manure and wastewater from an AFO.

3. **Nutrient Management** – This element addresses the requirements for land application of all nutrients and organic by-products (e.g., animal manure, wastewater, commercial fertilizers, crop residues, legume credits, irrigation water, etc.) that must be evaluated and documented for each Conservation Management Unit (CMU).

4. **Record Keeping** – This element lists documentation requirements associated with developing and implementing a CNMP. It is important that good records are kept to effectively document and demonstrate implementation activities associated with CNMPs.

5. **Feed Management** – This element addresses feed management activities as a possible opportunity for the AFO owner/operator in the CNMP development process. Feed management activities may be used to reduce the nutrient content of manure, resulting in less land being required to utilize the nutrient contents of the manure.

6. **Other Utilization Activities** – This element addresses other environmentally-sound utilization options associated with animal manure and wastewater as alternatives to traditional operational and land application methods

RECORD KEEPING FOR CNMPS

Sam Marshall
CAFO Coordinator
Tennessee Department of Agriculture
Ellington Agricultural Center
440 Hogan Road
Nashville, TN 37220

Ph: 615-837-5306; Fax: 615-837-5025
sam.marshall@state.tn.us

No Paper Submitted

Poster Presentations

POULTRY LITTER SPREADER CALIBRATION EDUCATION AND DEMONSTRATION

Thomas Bass[1], Peyton Sapp[2], Keith Fielder[3], Bobby Smith[4] and John Pope[5]
University of Georgia, Cooperative Extension Service,
[1]Biological and Agricultural Engineering-Athens,
[2]Greene County,
[3]Putnam County,
[4]Morgan County and [5]Monroe County

Over the last 4 years, great resources and time have been put into nationally recognized programs in nutrient and animal waste management conducted by UGA Extension specialists and county agents. An integral component to nutrient management planning is the calibration of land application equipment. In addition, new regulations from the GA Department of Agriculture now require haulers and brokers of animal manures to apply for a permit and annually calibrate application equipment. It is estimated that GA produces over 1.5 million tons of poultry manure annually. Spreader calibrations are imperative for the continued use of the manure resource in an environmentally responsible manner.

In March of 2004, Extension specialists and over 25 county agents field tested a variety of methods for poultry litter spreader calibration. The field day was promoted as an in-service training with an interactive component. It was cooperatively planned by five specialists as well as county agents from Greene, Morgan and Putnam Counties. During the training, five methods were each tested on four different spreaders at the UGA Central Branch Experiment Station in Eatonton. The results of this exercise allowed specialists to continue recommending the UGA small tarp method for litter spreader calibration. A convenient calibration kit was assembled to facilitate quick and easy replications in the field.

The next step in addressing this situation involved developing a curriculum for county and regional workshops. Monroe County Extension worked with Poultry Science and Bio and Ag Engineering to plan the first course on animal feeding regulations and nutrient management planning that also incorporated calibration of a spreader. The program consisted of a two hour classroom session covering: poultry regulations, litter and soil testing, farm mapping, nutrient management planning software and explanation of calibration. After a break, the group reconvened in the field for a hands-on demonstration and interpretation of the recommended "UGA small tarp method" for spreader calibration.

Five successful workshops have been conducted, one in central Georgia, one in south central Georgia, and 3 in south east Georgia, where over 200 producers, litter brokers and poultry company field men were in attendance. The compiled curriculum, set of presentations and calibration kit make this training easy to replicate. Requests for additional trainings have been received and will be accommodated to provide this pertinent and timely training in convenient geographic regions throughout the state. These trainings exemplify successful collaboration and cooperation between Extension specialists, county agents, local soil and water districts, NRCS and the poultry industry.

Additional Acknowledgements: Dr. John Worley, Mr. Paul Sumner, Dr. Casey Ritz, Dr. Mark Risse, Mr. Vaughn Calvert and Georgia's County Agents.

BACTERIAL COUNTS ASSOCIATED WITH COMPOSTING LITTER BETWEEN FLOCKS

K.S. Macklin, J.B. Hess, S.F. Bilgili, J.P. Blake and R.A. Norton
Department of Poultry Science, Auburn University
Auburn, AL 36849

Composting of used poultry litter is a common practice after it has been removed from a broiler chicken house. When composting is performed properly the used poultry litter is transformed into a stable relatively odorless compost product that is free of pathogenic bacteria. This resulting compost product can then be safely used to augment nutrients in the soil.

Between flocks, bacterial numbers in litter can be reduced either by desiccation aided by downtime, or by the addition of a litter treatment. Desiccation of the litter, though of no cost to the grower, may not maximize the potential bacterial reduction and does not insure that pathogenic bacteria are eradicated. Conversely, some litter treatments have been shown to significantly reduce bacterial numbers and to decrease or eliminate the number of pathogenic bacteria (Pope *et al.*, 2000). However the use of litter treatments adds an extra financial burden to the grower. Possible alternatives in reducing the bacterial numbers include in-house composting of litter between flocks. Composting between flocks, though labor intensive, would be a safer alternative than using toxic chemicals to reduce bacterial numbers in the litter.

Previous work has shown that composting of litter between flocks reduces bacterial numbers (Macklin *et al.*, 2003). In this experiment, composted versus non-composted litter was compared. Additionally the effect of adding water and/or covering the litter was evaluated to determine if these factors influence bacterial reduction.

Materials and Methods

Litter History: Four hundred straight run broiler chickens were obtained at 1 day of age and placed evenly into 8 pens (50/pen). Birds were reared under non-stressed conditions and given appropriate feed for a total of seven weeks.

Experimental Treatments: After bird removal, each of the eight 15.3ft x 7.0ft pens was divided in half to give sixteen 7.6ft x 3.5ft areas to work with. These work areas were then treated in one of eight possible ways as shown in Table 1. Composting of the litter was accomplished by piling the litter in the middle of selected pens. Half of the pens than had 2 gallons of water sprayed onto them. A tarp that was sufficiently large enough to cover the entire composted or non-composted area was than placed in half of the groups. This gave a total of 2 replicates for each treatment.

Temperature Readings: Ambient temperature and select litter temperature readings were taken every hour. Compost temperature readings were taken by placing the temperature probe approximately one foot into the center of the compost pile. Non-composted litter temperature readings were taken at a depth of approximately 6 inches.

Sample Collection: Litter samples were collected at the time of bird removal (time 0) and 1 week later (time 1) from each treatments. Collection of the litter in non-composted pens was bacteria was the treatment in which water was added to the litter and it was then covered (treatment C).

Discussion

In seven of the eight treatments there was a reduction in bacterial numbers, with the exception being treatment B. That treatment group was left untreated in the pen. After one week, there was little reduction in aerobic and no reduction anaerobic bacterial numbers in treatment B. In the other seven treatment groups, there was a reduction in aerobic and anaerobic bacterial numbers; however the greatest decrease in numbers was observed in the composted treatments.

For a compost pile to effectively reduce vegetative bacterial cells the temperature must rise above 130°F and maintain this temperature for three consecutive days (Dumontent *et al.*, 1999). However a 99.99% reduction in non-spore forming pathogenic bacteria has been reported when this temperature was maintained for 12 hours (Olsen and Larsen, 1987). In this experiment, only treatments G and H attained temperatures over 130°F, with treatment G being the only treatment to maintain this temperature for longer than 12 hours. Treatment G on the last two days of this experiment (days 6 and 7) was able to maintain 130°F for those two days. The results do not show an overtly greater reduction in bacterial numbers than the other effective treatments in this experiment. Perhaps if the experiment was given one more day there might have been a greater reduction in bacterial numbers. One question that was not addressed in this experiment was what bacteria were recovered? Perhaps the majority of the bacteria counted in treatment G were spore forming mesophilic bacteria or perhaps thermo tolerant mesophilic bacteria.

The effects of composting the litter compared to not composting are significant. The overall reduction in bacterial numbers in the composted treatments E, F, G, and H in this experiment were overall significantly greater than those four treatments that were not composted (A-D). The only non composted treatment that had reductions in both aerobic and anaerobic bacterial counts was treatment C. This is of interest since this treatment, though not composted, did have water added to it and it was covered; however this treatment never achieved temperatures high enough to kill bacteria. Ammonia levels in treatments that were covered were substantially more noticeable than those that were not. The addition of water would contribute to the ammonia build up by providing an important substrate to the bacteria to produce ammonia. Covering the litter with a tarp would act as a barrier that allowed ammonia to build up in the litter and contribute to decreasing bacterial numbers. This decrease would be due to a reduction in the oxygen tension in the covered groups as well as due to the toxic effect of ammonia

Temperature and ammonia levels effect inactivation of viruses. Reduction in active viral numbers by a factor of 10^{15} can be achieved by maintaining a temperature of 130°F for 2.5 days (Burge *et al.*, 1987). Ammonia inactivates viruses when the pH is greater than 6 (Fenters *et al.*, 1979). In this experiment, virus load in the litter was not determined nor was the litter pH. However given the high temperatures achieved by two of the composted treatments (G and H) and the high ammonia levels present in all of the covered treatments (A, C, E, and G) it is conceivable that there was also a significant reduction in viral numbers in these treatments as well.

Future work will address the issues mentioned above as well the use of a passive aeration system with the composted litter. Passive aeration may allow the compost pile to achieve and sustain the desired temperature of 130°F by allowing oxygen easier access to the interior of the compost pile.

POTENTIAL AIR PERMITTING PROCESS FOR POULTRY WASTE MANAGEMENT

Mark Saito
Senior Meteorologist
Burns & McDonnell Engineer, Inc.
9400 Ward Parkway
Kansas City, MO 64114
816-822-3914
msaito@burnsmcd.com

Air permitting will become a part of the operation of many poultry farms. For the past eight years, the U.S. Department of Agriculture's Agricultural Air Quality Task Force (AAQTF) has fulfilled a Congressional mandate to determine the extent to which agricultural activities impact the nation's air quality. An inevitable result of the AAQTF's findings will be regulation of sources of air pollutants from poultry animal feeding operations (AFO). This poster display examines some of the emerging issues that the AAQTF is discussing, and then describes what a resulting air permitting application may include.

The AATQF has listed a number of emerging issues key to the progress of satisfying its Congressional mandate. The three issues that will have the greatest impact on permitting poultry feeding operations are:

1. Development of emission factors.
2. Volatile organic compounds (VOC) emissions from agricultural operations.
3. Quantification of reductions associated with Best Management Practices (BMP).

These three issues quantify the potential emissions from a poultry AFO and may determine whether the AFO is a major source or not. If the AFO is a major source, then the air permit will consist of the following steps:

1. Applicability of the source(s).
2. BMP Analysis.
3. Air Quality Analysis (Based on newly developed emission factors).
4. Additional Impacts Analysis (What impacts the AFO may have on soil, vegetation, and odors.)
5. Class I Area Analysis (Potential impacts on nearby pristine national parks or wildlife refuges).

NEW APPLICATOR TECHNOLOGIES FOR MANURE

Darrell M. Steiner
Industrial Sales Manager
Ag-Chem Equipment Co.
13625 Geyser Path
Apple Valley, MN 55124
952-891-4567 office
952-891-6083 fax
darrell.steiner@agcocorp.com

ABSTRACT

Many concerns are raised by large animal feeding operations with concentrated manure such as, amount and quantity of pathogens present, odor, heavy metals, runoff, loss of nitrogen and phosphorus pollutants.

Ag-Chem Equipment Company has developed one solution. We call it the Nutrient Management System. We use the latest Global Positioning Systems (GPS), combined with state of art GIS software called SoilTeq Geographical Information System (SGIS)™ developed by SoilTeq® and Falcon II® computer controller to match crop nutrient requirements to the nutrient makeup in the manure.

This fully integrated system is a four-step process.

Step One:

In this step you compile data such as manure nutrient content, soil grid tests, yield goals, soil surveys, etc. This information is critical to establish the base line for the nutrients to be applied to each of the fields.

Step Two:

Through SGIS and your local agronomy recommendations, a manure application map can be created. This map will indicate the precise amount of manure to be applied across the field for crop nutrient requirements. Where limitations of manure nutrient content exist, commercial fertilizers can be injected into the slurry or variably applied to make up the difference. In addition, no apply zones or buffer zones can be included in the application map. For other biosolids, which contain metals, a map can be created to the desired level to be applied.

Step Three:

The manure is then variably applied through the use of the Falcon computer controller and Global Positioning (GPS) located on board the Terra-Gator 3104 or 9105 NMS machine.

Step Four:

The Falcon computer controller also generates an electronic record of what, when, where, and how much manure was applied. This "as applied" report can be used for further agronomic analysis or compliance records.

AMENDMENTS FOR THE REDUCTION OF WATER SOLUBLE PHOSPHORUS IN BROILER LITTER

Armando S. Tasistro
Soil, Plant, and Water Laboratory
University of Georgia
2400 College Station Road, Athens, GA 30602-9105
Ph: (706) 542-5350; Fax: (706) 369-5734
tasistro@uga.edu

David E. Kissel
Soil, Plant, and Water Laboratory
University of Georgia
2400 College Station Road, Athens, GA 30602-9105
Ph: (706) 542-5350; Fax: (706) 369-5734
dkissel@uga.edu

Introduction

Broiler litter is commonly broadcast on pastures in North Georgia and it can become a major non-point source of phosphorus, especially when high rates are applied and rainfall occurs shortly after application. Dissolved phosphorus in runoff water is a prime cause of surface water degradation (Sims and Wolf, 1994), thus the need for management practices that limit the risk of phosphorus transport to water bodies has become more pressing.

Applying amendments with high P-fixing capacity at clean out could reduce water-soluble P concentrations in broiler litter. Aluminum sulfate has been used commercially to control NH_3 release in chicken houses, and it can reduce the concentration of water soluble P (Moore et al., 1996). Other potentially successful amendments include salts containing Fe and Ca. In this study, we compared the efficacy of four inorganic salts (Al sulfate, Fe sulfate, Fe chloride, and gypsum) and two soils (Houston Black clay and Cecil) on the concentrations of forms of water soluble P when measured immediately and 48 h after treatment. The two soils were selected as both are known to have high P fixing capacities. The rationale for choosing two time intervals was to explore if producers need to wait between the treatment of the litter and its field application. We do not have precise information about the preferences of producers in relation to the period between clean out and field application, so 0 and 48 h after treatment application were selected arbitrarily.

Materials and Methods

We used a sample of caked broiler litter from a commercial farm in Georgia after six flocks, and that contained 280 g water kg^{-1} and 13, 580 mg P kg^{-1} on a wet basis. Moisture was determined by measuring weight loss in 110-120 g broiler litter samples after drying in a forced draft oven for 48 hours at 65°C. The concentration of total P was measured by Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES) after microwave enhanced digestion in concentrated HNO_3.

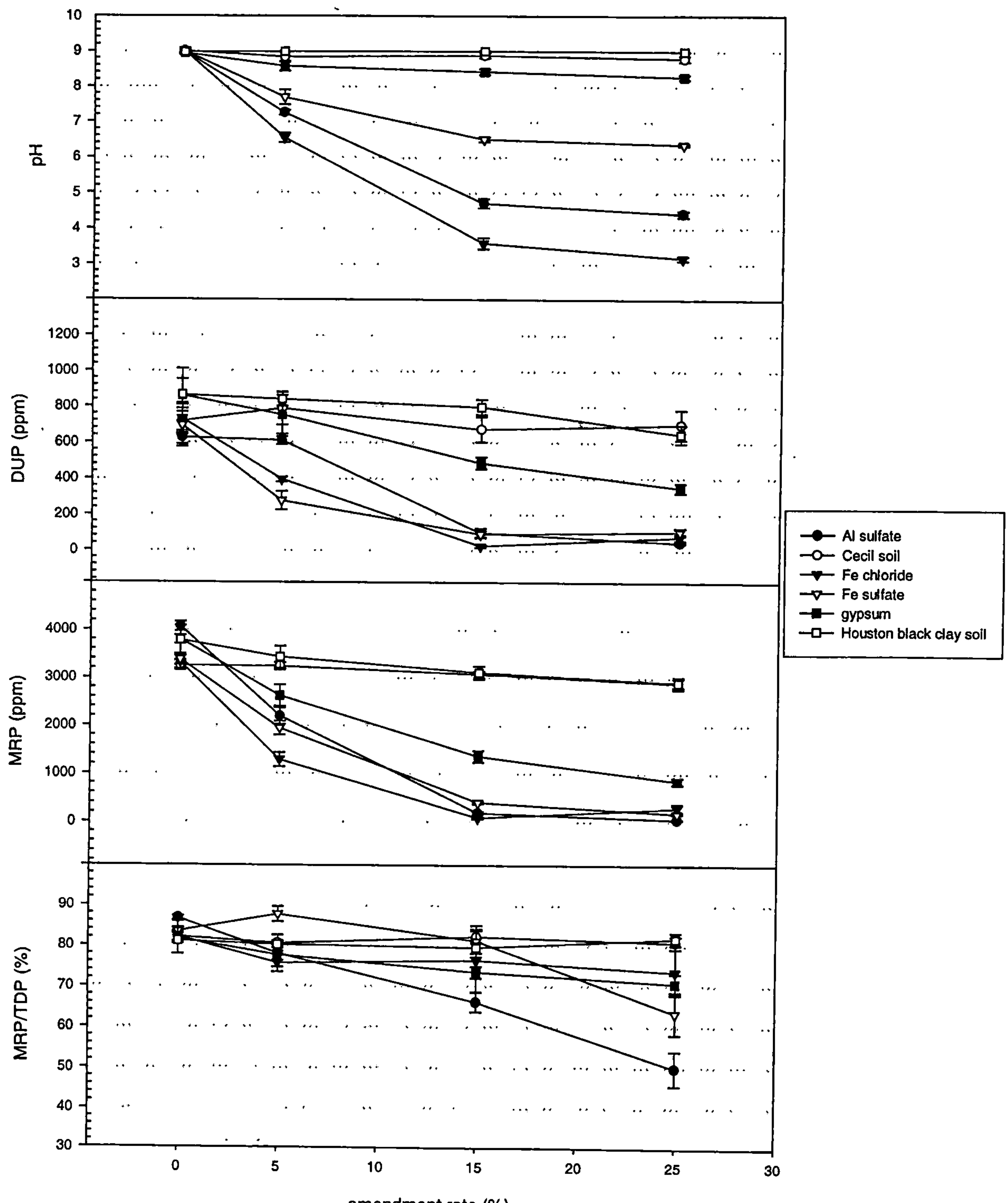


Figure 1. Effect of five amendments applied at four rates on the pH, concentrations of DUP and MRP on an "as is" basis, and the MRP/TDP ratio of broiler litter