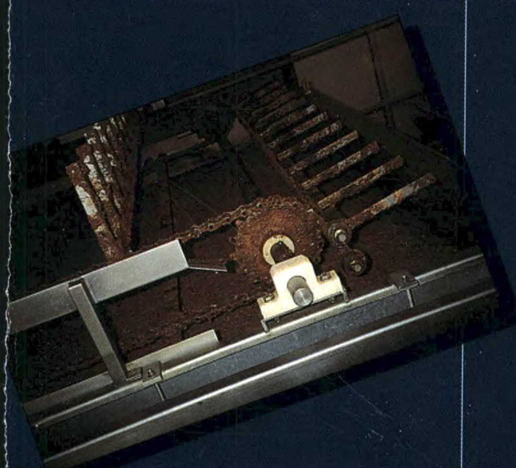
PROCEEDINGS

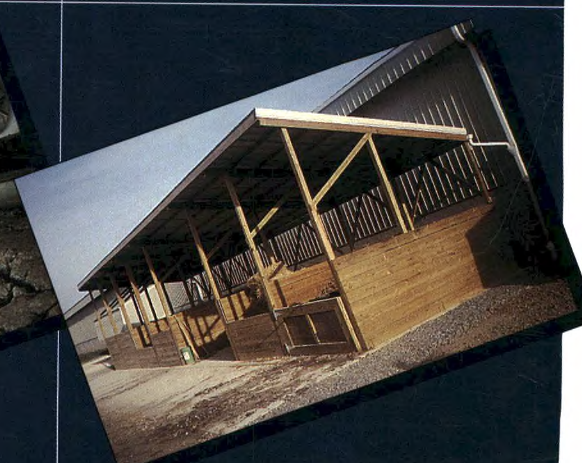
Edited by P.H. Patterson and J.P. Blake

1994 National Poultry Waste Management Symposium



RECYCLING

- Manure
- Dead birds
- Water



Proceedings

1994 NATIONAL POULTRY WASTE MANAGEMENT SYMPOSIUM

Edited by:

Paul H. Patterson
Department of Poultry Science
The Pennsylvania State University

John P. Blake
Department of Poultry Science
Auburn University

Published by

National Poultry Waste Management Symposium Committee

First Published 1994

Cover Photos Courtesy of:

James O. Donald
Department of Agricultural Engineering
Auburn University, AL

Leon J. Ressler
Lancaster County Extension Service
Lancaster, PA

Paul H. Patterson
Department of Poultry Science
The Pennsylvania State University
University Park, PA

ISBN 0-9627682-6-4

Printed in the United State of America
Auburn University Printing Service
Auburn University, AL 36849

TABLE OF CONTENTS

GENERAL SESSION

Jesse Grimes Moderator
Department of Poultry Science
North Carolina State University

PRODUCTION

Managing Nutrients

Joseph Claybaugh, Moderator
TWJ Farms
Carroll, NE

Nutrient Regulation Through Feed Formulation

Sally Noll, Moderator
Department of Animal Science
University of Minnesota

PROCESSING

Strategies for DAF Biosolids Management

Ed Schwille, Moderator
Poultry Water Quality Consortium
Chattanooga, TN

Stormwater Management

Jim Walsh, Moderator
Georgia Tech Research Institute

PRODUCTION

Alternative Methods of Handling Waste

John Blake, Moderator
Department of Poultry Science
Auburn University

Right-to-Farm Issues

Ralh Ernst, Moderator
Department of Avian Sciences
University of California

PROCESSING

Waste Water Treatment

James Donald, Moderator
Department of Agricultural Engineering
Auburn University

Water Recycling in Processing

Pat Curtis, Moderator
Department of Food Science
North Carolina State University

POSTER PRESENTATIONS

PROCESSING WORKSHOP

Coordinated by:

Lewis Carr	University of Maryland
Tim Foutz	University of Georgia
Carl Johnson	Perdue Farms, Salisbury, MD
William Merka	University of Georgia
James Walsh	Georgia Tech Research Institute

1994 NATIONAL POULTRY WASTE MANAGEMENT SYMPOSIUM

DATES:

October 31 - November 2, 1994

LOCATION:

Holiday Inn
Athens, GA

PREFACE

Early in 1987, an informal meeting was held to discuss poultry waste management and the need to organize a national meeting on the topic. Since this inception, three National Symposia have been held in 1988, 1990, and 1992. Today, environmental concerns for the quality of air we breathe, water we drink and the environment we habitate are on the minds of most Americans. It is my observation that the majority of the people in the poultry industry share the same concerns and goals for a better environment. With this Fourth National Symposium and Proceedings, the Program Committee hopes to further the understanding of waste management issues and provide some solutions to the betterment of our national environmental resources.

The 1994 Symposium begins with a general session covering topics on the horizon including regulatory implications of the clean air and clean water acts. Concurrent sessions devoted to poultry production and processing topics follow with additional research and technologies presented in posters and commercial exhibits. The final day is devoted to tours of production facilities managing mortalities and litter, and a hands-on processing workshop with waste stream problem solving. The Proceeding serves to disseminate this wealth of information to others that were unable to attend. Previous orders for the Proceedings have increased dissemination three-fold from symposium attendance and confirmed our impressions that interest in waste management issues is building.

The Program Committee wishes to thank all persons, exhibitors and 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, as necessary, by the editors. The manuscripts were not evaluated by a peer review process. We wish to thank those authors who diligently prepared their manuscripts in a timely fashion to allow its dissemination at the Symposium.

Unless otherwise stated, mention of trade names in this Proceedings does not imply endorsement by the editors or Symposium sponsors.

Paul H. Patterson
John P. Blake

Editors

Program Committees

Program Committee Chair- and Co-persons

Coordinator	Richard Reynnells, USDA/ES, Washington, DC
General Session	Jesse Grimes, North Carolina State University Ellis Brunton, Tyson Foods, Sprindale, AR
Production Session	Joseph Hess, Auburn University Joseph Claybaugh, TWJ Farms, Carroll, NE
Processing Session	Lewis Carr, University of Maryland Carl Johnson, Perdue Farms, Salisbury, MD
Poster Session	Kenneth Anderson, North Carolina State University Michael Wineland, North Carolinia State University
Exhibits	Glenn Carpenter, North Carolina State University Thomas Carter, North Carolina State University
Finance	John Schwartz, The Pennsylvania State University
Publicity	Michael Ouart, University of Florida
Proceedings	Paul Patterson, The Pennsylvania State University John Blake, Auburn University

Additional Program Committee Members*

Lionel Barton	University of Arkansas
Julian Brake	Virginia Tech
Thomas Carter	North Carolina State University
Eldridge Collins	Virginia Tech
Dan Cunningham	University of Georgia
James Donald	Auburn University
Ralph Ernst	University of California
David Frackelton	WLR Foods, Inc., VA
Jim Freiss	Wayne Poultry, GA
Mike Hulet	The Pennsylvania State University
Mike Lacy	University of Georgia
Bill Merka	University of Georgia
Gerald Murphy	Rocco Turkeys, VA
Gene Newman	Tyson Foods, AR
Dan Palmer	University of Delaware
James Parsons	North Carolina State University
Tony Pescatore	University of Kentucky
Jim Rock	University of Connecticut
Ed Schwille	Tennessee Valley Authority, TN
John Starkey	Hudson Foods, AR
Joe Vandepopuliere	University of Missouri
Jim Walsh	Georgia Tech Research Institute

*As stated in the acknowledgements, many more people contributed to the final program.

Local Arrangements Committee

William Merka, Chair

Wanda Linker, Coordinator

Members

James Donald
Michael Lacy
Larry Vest

Acknowledgements

The organization and administration of a successful symposium requires diligence and cooperation of many individuals and organizations. This symposium is no exception. The cooperation among the committees and the dedication and perseverance by the committee chairs is greatly appreciated. A thank you is deserving of those who were involved in the planning and execution of this workshop.

The organizing committee would like to recognize Alabama Poultry and Egg Association for their coordination of registration and local arrangements. Their involvement has definitely contributed to the success of this symposium.

The editors and organizing committee are indebted to Patricia Owen for her technical assistance and dedicated efforts in ensuring the quality and timeliness of this proceedings.

CONFERENCE INTRODUCTION

Richard D. Reynnells
National Program Leader, Poultry Science
US Department of Agriculture
Room 3334 South Agriculture Building
Washington, DC 20250-0911

This symposium is a continuation of the highly successful series started in 1988 by Extension Poultry Specialists from throughout the USA. The purpose at that time, and today, was to address emerging issues related to the management of poultry wastes from production and processing facilities.

There has been some debate regarding the use of the term waste. In fact, for the 1992 meeting we received national recognition of sorts when Lewis Grizzard wrote a "tongue in cheek" article about our discussions. We probably should refer to the manure, litter, sludges and other by-products of producing poultry products as a resource and provide a better term to describe these by-products. The days are long gone when we can, or should, treat these materials as waste and something to just get rid of. However, we also can not become enamored with semantics if this reduces our capacity to concentrate on the real issues of waste management. Only by focusing our efforts to optimize the returns or minimize the losses from wastes do we realize their potential as a valuable resource.

Recycling and obtaining the optimal utilization of inputs (through not wasting wastes) not only can optimize profits, but are environmentally friendly. These techniques are also an important part of a good neighbor policy, and help keep regulatory agencies from having a valid reason to mandate production practices for agriculture.

In keeping with the need to stay ahead of the curve on waste management issues, we have refocused the program away from dead bird disposal to other presentations dealing with pollution prevention. One rarely hears discussions of whether we need to address environmental issues. The discussions are of how we will do this, and what is the most expedient mechanism to achieve environmental stability.

The speakers were chosen to predominately address various aspects related to concerns generated by local and national regulations related to the Clean Air Act, Clean Water Act and Coastal Zone Management Act. We also cover the additional important issue of manure nutrient regulation through feed formulation, which ties in directly with the nutrient management plans of best management practices. Composting considerations and opportunities are covered in both the production and processing sections. Right to farm presentations exam the legal and practical solutions to living in a more complex society, and the need for each company to develop a good neighbor policy.

The 1992 meeting initiated: a poster presentation session, with author's comments being included in the proceedings; a hands-on processing workshop; and, an industry tour. These programs were very successful, and are continued for this symposium. For the first time in this series, we are featuring an international speaker, and a representative from an environmental group. Mr. Nick Nicholson, from Cambridge, England, will discuss environmental regulations and the related nitrogen utilization concerns from the European standpoint. Karen Firehock represents the Izaak Walton League of America, and will present a detailed view of how the poultry industry can better fulfill their social responsibility regarding environmental issues.

Participants at the symposium have been provided a copy of the proceedings. Additional copies are available for $25, plus $5.00 for postage and handling from:

Dr. John P. Blake
Department of Poultry Science
Auburn University
Auburn, Alabama 36849-5416

Telephone: 205/844-2640
Fax: 205/844-2641

Please make the check payable to:

National Poultry Waste Management Symposium

The primary purpose of this series of meetings is to address the current and projected educational needs of the poultry system (industry, university, government) in the area of poultry waste management. Therefore, it is very important that each person provide feedback to the organizing committee regarding each aspect of the program. If at a later time you discover a topic or speaker you would like to see for the 1996 meeting, please contact the coordinator or any committee member. Also, if you would like to volunteer as a committee member for future programs, we welcome your participation. We have selected Pennsylvania as the site for the 1996 meeting, and would appreciate your comments so we may develop another strong program which will benefit the poultry system.

GROUND WATER POLLUTION PREVENTION REGULATIONS FROM THE STATE AND LOCAL PERSPECTIVE

Jerry L. Boling
RC & D coordinator
Chestatee-Chattahoochee
Resource Conservation and Development Council, Inc.
524 Green Street, NE
Gainesville, GA 30501

The growing market for "bottled spring water" in 1 gal. or 5 gal. jugs sold in supermarkets or delivered to your office is evidence that for some, any tap water is suspect. Attitudes about pollution of ground and surface water are part myth, fear, hope and ones background.

Local governments are given responsibility for implementing environmental protection programs, often without new resources and usually lacking staff. Many elected officials are beginning to question mandates from State and Federal levels and this may appear to the public that they don't support environmental protection programs.

The poultry industry is vital part of the economy in Georgia that has been good for the farmers by providing them with higher farm income and good for the State because of the many agri-related jobs that poultry supports. The industry realizes that changes are taking place in the rural area populations and old methods of disposal of manure and poultry mortality may not be acceptable by the neighbors and it may not meet waste quality standards.

In my role as resource conservation and development coordinator, working with 13-county governments in northeast Georgia and numerous city governments and a number of agriculture groups, I have yet to find a county commissioner, a farmer or a Corp. CEO that did not want to protect the environment. But, I have spent many hours trying to help them find solutions that were practical, affordable and workable.

Efforts are already underway in Georgia to test and demonstrate new methods of animal waste management that are more environmentally acceptable. The Chestatee-Chattahoochee

RC&D Council, Inc. has sponsored and coordinated innovative projects... (1) identify non-point sites that have potential impact on ground water and surface streams, (2) demonstrated composing of manures to reduce nitrates, (3) tested an alternative to disposal of poultry mortality by digester system rather than placing in ground pits, (4) demonstrated a new method of heavy use area stabilization for dairies.

GROUND WATER POLLUTION PREVENTION REGULATIONS FROM THE STATE AND LOCAL PERSPECTIVE

Kay Harker
Kentucky Department of Environmental Protection
Frankfort, KY

GROUND WATER POLLUTION PREVENTION REGULATIONS FROM THE STATE AND LOCAL PERSPECTIVE

Hank Zygmunt
Section Chief
Nonpoint Source Department
Environmental Protection Agency
U.S. EPA Region III
841 Chestnut Building
Philadelphia, PA 19107

There are areas in Region III of the EPA which demonstrate detrimental effects of poultry waste on the local environment. Delaware, especially, is heavily represented by the poultry industry. Because of these large concentrations, we are seeing higher than desired levels of nitrate in the ground water. EPA's drinking water standard for nitrate is 10 mg/l. In a report on the Delmarva National Water Quality Assessment program it is noted that the highest levels of nitrate in the groundwater were found, in most cases, near poultry farming operations. More than 34% of wells tested in Sussex county had nitrate concentrations greater than the EPA drinking water standard. This is attributed to over application of poultry manure.

Similarly, a report on the Inland Bays project in Delaware reported that the poultry industry was a major source of excessive nitrates in the study site, especially in groundwater. One study, in particular, measured nitrate levels of over 100 mg/l in the ground water below several poultry houses. They have also found nitrates in excess of 10 mg/l in over 20% of the wells in the area.

As we know, nitrate in high concentrations can be harmful. High levels of nitrate can put babies at risk by causing the "blue-baby syndrome". Also, studies correlate gastric cancers with nitrate ingestion. Animals, too, are at risk. High abortion rates and lower milk productivity in dairy herds in some areas have been attributed to high nitrate concentrations.

Existing regulations in places which deal with the environmental problems linked with the poultry industry are few. In 1990, the Pollution Prevention Act was passed which calls pollution prevention a "national objective". The act directs EPA to facilitate the adaption of source reduction techniques by business and federal agencies, to establish standard methods of measurements for source reduction, to review regulations to determine their effect on source reduction, and to investigate opportunities to use federal procurement to encourage source reduction.

The Clean Water Act establishes the statutes zero discharge goal in section 101. Section 101(b)-(c) expresses zero discharge in terms of prevention, reduction, and elimination of pollution. The statutory presumption that all discharges are illegal, except where permitted, embodies a preventative approach to regulation. Section 307(a)(2) empowers the agency to impose an effluent standard which may include a prohibition for the discharge of toxic pollutants based solely on health and environmental concerns.

Otherwise, there are not many other pollution prevention regulations set up by the federal government. Most of the poultry projects which are funded in Region III are done so through section 319 of the Clean Water Act. Examples of these projects are:

> Lunice Creek Subwatershed Poultry Production and Resource Management, West Virginia, FY 1994. This project concentrates primarily on nutrient and pesticide management. The objective is to decrease nutrient and pesticide contamination of surface and ground water resources by implementing an information and education program for water quality issues and nutrient management. The project will also research other alternative uses for poultry litter. One example of this is as cattle feed. The federal share of this project is $36,150 while the state's participation if $24,100. The partnerships involved in this project are the WVSSCC, WVDA, WVU CES, USDA SCS, US EPA, USDA ASCS, Potomac Valley Soil Conservation District, Farmer's Home Administration, the Poultry Growers Association and the Poultry Water Quality Committee.
>
> North and South Mill Creek Poultry Production Resource Management, West Virginia, FY 1994. This is a similar project which concentrates primarily on nutrient and pesticide management. The objective is to decrease nutrient and pesticide contamination of surface and ground water resources by information and education. Nutrient management is also an important part of this project. The federal share of this project is

$15,750 and the State contribution is $10,600. The partnerships involved in this project are the same as in the Lunice Creek Project.

Nitrogen barriers for Broiler Houses for Groundwater Protection, Delaware, FY 1991. This project looks at using barriers (soil cement) in broiler houses to reduce the amount of contaminants from broiler houses reaching the ground water. The federal share on this project is $35,000 and the state project is $24,000. The partnerships in this project include the University of Delaware, US EPA, DNREC, USDA SCS, Sussex Conservation District and the Cooperative Extension Systems farmers.

Reducing water quality impacts from Virginia's Poultry Industry, Virginia, FY 1991. The goal in this project is to reduce negative water quality impacts associated with high loading rates and inefficient use of poultry manure by encouraging transportation of litter to areas where litter can be used efficiently with greatly reduced water quality impacts. The project will increase demand for the litter through several demonstration projects using litter as feed and fertilizer. The federal share of this project is $30,510 and the state share was $0. The partnerships involved in this project include VA's Department of Conservation and Recreation, Division of Soil and Water Conservation, Virginia Cooperative Extension, VPI&SU Animal Science Department, Northern Piedmont Agricultural Experiment Station, the Poultry Federation, and various conservation districts.

GROUND WATER POLLUTION PREVENTION REGULATIONS FROM THE STATE AND LOCAL PERSPECTIVE

W. Arthur Darling
Environmental Specialist
Dairy Farmers, Inc.
P. O. Box 547775
Orlando, FL 32854-7775

In Florida, groundwater protection pollution prevention and/or cleanup is the purpose of various statutes, rules and agencies. I will confine my remarks to those effecting animal agriculture. Whether beef cattle, dairy cows, swine, poultry or turkeys, the main groundwater threat posed by animal agriculture is the leaching of excess nitrates from manure to groundwater.

Unfortunately, over-applications of inorganic fertilizer can cause the same problem. According to one researcher at the University of Florida, it takes only 20 pounds more nitrogen than the crop needs to cause an excess nitrate problem in deep sand soils with an unconfined aquifer--which is not uncommon in much of Florida.

Prior to 1979 groundwater was essentially unregulated and unprotected. On March 1, 1979, Florida's Department of Environmental Protection (DEP) implemented its first serious ground water provisions into the Florida Administrative Code. The first provisions divided groundwater into two classifications and set groundwater quality standards for these classifications. These rules first introduced the concept of a "zone of discharge". Except for certain substances at concentrations which constitute a serious danger to the public health, safety or welfare (commonly referred to as "free froms"), groundwater quality standards were applicable at the boundary of the permitted zone of discharge.

The DEP exercises regulatory authority over groundwater contamination under Florida Statutes. Groundwater is protected through permitting requirements, monitoring programs, drinking water protection programs and policies, use of hazardous waste laws such as the federal Response

Conservation Recovery Act, Florida's "little" Comprehensive Environmental Response and Clean-Up Lability Act program regulating clean up of hazardous wastes and substances, and through DEP's "ground water rule" with its related groundwater quality standards.

Florida's five water management districts: 1) regulate groundwater contamination in terms of contaminants such as chlorides induced through overuse of the resource (i.e., salinity contamination from coastal consumptive use), 2) regulate groundwater impacts of agricultural activities under the Warren S. Henderson Wetlands Protection Act of 1984.

Many local agencies and regulations govern and seek to restrict groundwater contamination in Florida. The most important categories are approved local pollution control programs and county water resource management programs. Local requirements usually apply in addition to state and federal regulations. Local groundwater requirements have become increasingly important, particularly with respect to implementation of their land development regulations. The nature and extent of each local program varies. Several counties have adopted well field protection ordinances. Some counties have adopted underground storage tank ordinances that have been approved by DEP.

The U. S. Environmental Protection Agency entered the realm of groundwater discharge permitting under the Safe Drinking Water Act's underground injection control (UIC) permitting process. Under this program, the discharges of waste into ground water are regulated through a permitting process in a system of classification of injection wells and through the establishment of injection well construction standards.

DEP jurisdiction is set forth in the state's statutes and Administrative Code Chapters, as well as the Federal Safe Drinking Water Act, from which DEP's program originates. Some farms who provide worker housing or have over 25 employees full-time have been cited because they exceed one of the following definition thresholds:

Community water system - serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents.

Non-community water system - serves at least 15 service connections <u>or</u> serves at least 25 individuals at least 60 days out of the year.

Non-transient non-community water system - is a public water system that is not a community water system and that regularly serves at least 25 of the same persons over 6 months per year.

Primary drinking water standards are those contaminants which, in the judgment of DEP, after consultation with Health and Rehabilitative Services (HRS), may have an adverse effect on the health of the public include: inorganics; organics; turbidity; microbiological and radionuclides.

Secondary drinking water standards specify the maximum contaminant levels which, in the judgment of DEP after public hearings, are requisite to protect the public welfare. They are listed by Rule.

Unregulated contaminants only have monitoring requirements (no maximum contaminant levels ("MCL's") for community water systems and non-transient non-community systems.

The contaminants listed above have specific sampling and analyses requirements.

The DEP is currently developing a statewide wellhead protection program. Actions to be taken to achieve a statewide program include:

* Adopt, by rule, minimum statewide delineation criteria for wellhead protection areas (or different delineation criteria for Florida's various hydrogeological settings).

* Adopt, by rule, more stringent groundwater discharge criteria for facilities located in wellhead protection areas for which a need for enhanced protection has been demonstrated.

* Establish, by rule, criteria for recognizing "adequate" local wellhead protection programs based on delineated wellhead protection areas and management criteria implemented within those areas.

When a local program is determined to be "inadequate" or is non-existent, the Department will adopt, by rule, wellhead protection areas and implement applicable discharge criteria.

Part of the program's objectives is to enhance groundwater monitoring, compliance, inspection, and enforcement activities for Department regulated facilities in all wellhead protection areas, whether adopted by the Department or by local government.

Since the DEP believes land use controls are the most effective protection, the Department will establish a program, in conjunction with water management districts, to provide guidance and technical assistance to local governments.

GROUNDWATER ISSUES RELATED TO AGRICULTURE

Cattle Dipping Vats - From 1913 until about 1958, approximately 3500 cattle dipping facilities or vats were constructed and operated in Florida to eradicate the cattle fever tick. Disease due to the cattle fever tick had caused significant damage to the cattle industry, and resulted in a strict federal quarantine and treatment program. While these vats are no longer in operation, they may pose a threat to groundwater quality and public health.

Cattle dipping vats were constructed throughout Florida's cattle producing areas. Cattle, horses and other animals were dipped regularly in solutions of arsenic, DDT, and some toxaphene. These materials were allowed to drip from the animals, and were routinely pumped from the concrete-bottomed vats for disposal to land surface.

Recently, a number of vat sites have been brought to DEP's attention through land transactions (many involving state land purchases). Site assessments have revealed significant residues of arsenic, DDT and other materials in soils and groundwater. No soil, water, or locational data exist with which to assess the potential impact of vat sites which may have been developed into residential or other land uses. The Department is developing a response policy in conjunction with the Department of Agriculture and Consumer Services (DACS). Substantial debate exists about liability issues associated with assessment and possible clean up of vat sites in Florida. Attempts to pass Legislation failed but will likely be filed in the 1995 session.

NITRATE IN GROUNDWATER ASSOCIATED WITH FERTILIZERS

Since 1984, Florida's DEP and Department of Health have been sampling drinking water wells (primarily domestic wells) in agricultural production areas to survey for residues of pesticides. When nitrate was added to the survey in 1989, the Department identified areas of serious nitrate contamination. Based on sampling results (e.g., co-contamination with pesticides), a knowledge of background levels of nitrate in those areas, information about high fertilizer use rates, and results of water quality studies for septic tanks, the Department has proposed that fertilizers represent the major source of this contamination. The most seriously affected area is in the Central Florida citrus producing counties. For example, testing in Highland County continues to identify approximately 33% of wells tested as contaminated with nitrate at levels in excess of the federal and state standard of 10 mg/L. A nitrate problem has also been identified in fern growing areas and a potential threat from animal manure at dairy and poultry operations exists in karst-prone areas of North Central Florida. University research did confirm leakage from a dairy lagoon causing elevated nitrate levels at one dairy farm.

The Department has initiated a significant effort in restoration and replacement of nitrate contaminated drinking water wells. This involves installation of point-of-use filtration devices (reverse osmosis), or extension of, and connection to, public water systems. Costs for work to address wells presently known to be contaminated will reach about $1.5 million. Sampling continues to identify additional contaminated wells in citrus producing areas on sandy soils.

In response to this problem, the DEP is administering grants and cooperating with Department of Agriculture and the citrus industry to develop improved and research-based fertilizer management practices, and is working with the University of Florida to revise fertilizer recommendations for ferns and citrus to take groundwater quality into consideration. The Department is participating in a project with the Department of Agriculture and University of Florida to compliment its study of fertilizer management to protect groundwater.

The 1994 Legislature passed a bill placing a 50 cent tax on every ton of nitrogen containing fertilizer. The statute exempts landowners from contamination penalties if they implement those fertilizer BMPs to be recommended by the state's department of agriculture in consultation with the university and DEP. Department of Environmental Protection will use the fertilizer tax revenues to provide clean water to those private well owners needing assistance.

In Florida, the groundwater standards are equivalent to the drinking water standards. By definition, a violation of any groundwater standard or criterion constitutes pollution. Groundwater discharges must also meet surface water standards for the contiguous surface waters which will be affected. Compliance with groundwater standards is determined based on analyses of unfiltered samples, except in the instance where a filtered sample is as or more representative of the particular groundwater quality.

MINIMUM CRITERIA FOR GROUNDWATER

This rule applies to all groundwater at all times and all places and is generally referred to as the "free froms" requirement. This rule prohibits any discharge in concentrations which, alone or in combination with other substances: 1) are harmful to plants, animals or organisms, 2) are carcinogenic, mutagenic, teratogenic or toxic to human beings, 3) are acutely toxic to indigenous species of significance to the aquatic community within affected surface waters, 4) pose a serious danger to the public health, safety or welfare, 5) create or constitute a nuisance or 6) impair the reasonable and beneficial use of adjacent water.

GROUNDWATER PERMITTING REQUIREMENTS

Unless exempt, no installation shall discharge into groundwater, either directly or indirectly, any contaminant that causes a violation in the water quality standards and criteria for the receiving groundwater, except within a zone of discharge established by permit or rule.

Whenever possible the Department incorporates groundwater discharge considerations into other appropriate Department permits and does not require a separate permit for groundwater discharges. The notice of proposed agency action is required to notice that groundwater considerations are being incorporated into such other permits.

No zones of discharge are allowed for discharges through wells or sinkholes that allow direct contact with Class G-I or Class G-II groundwater. Exemptions do exist for certain specific recharge wells. This zone of discharge limitation also applies to discharges that may cause an imminent hazard.

Zones of Discharge - Generally, no zones of discharge are allowed for discharges to Class G-I. Limited exceptions include the following:

* Domestic wastewater and stormwater sites authorized by the Department shall have zones of discharge extending no more than 100 feet from the site boundary or to the installation's property boundary, whichever is less. However, a smaller zone of discharge may be established if it is necessary to protect the designated use of adjacent waters outside the zone of discharge.

* Other discharge sites may be granted zones of discharge of the same size as the domestic wastewater and stormwater

sites provided the discharges are as clean as the domestic waste (i.e., the discharges meet the chemical, physical and microbiological standards of Rule 17-600.420, Florida Administrative Code).

* Installations authorized to discharge to groundwater at the time of reclassification to Class G-I shall meet the same requirements as existing installations discharging to Class G-II groundwater.

Generally, with respect to installations discharging to Class G-II and Class G-III groundwater, the boundary of the zone of discharge shall be 100 feet from the site boundary or to the installation's property boundary, whichever is less. A smaller zone of discharge may be established if necessary to protect the designated use of contiguous waters such as an Outstanding Florida Waters which are given special protective status by the Department.

* Existing installations shall have the zone of discharge specified in the permit or, if no zone of discharge is defined in the permit, extending to the owner's property line.

* New installations may establish a larger zone of discharge upon meeting the certain requirements provided the zone of discharge does not extend beyond the permit applicant's property boundary.

Monitoring

Generally, all installations (new and existing) must have approved monitoring programs. When the monitoring requirement was promulgated, existing operations were given a compliance schedule.

The contents and approval of the monitoring plans are done on a case by case basis. A DEP rule provides a list of information generally required for the site that may be considered.

Certain domestic sewage treatment installations; stormwater facilities; agricultural fields, ditches and canals; and livestock waste lagoons are exempt from the groundwater monitoring requirements. However, the dairy industry has been informed that a state-wide dairy rule will be established in the near future which will likely require groundwater monitoring of existing farms. The rule--in some form--may later be extended to other intensive animal facilities including poultry operations.

Statutory Authority

DEP has authority to pursue judicial or administrative remedies in response to violations. DEP's options include:

* Filing a civil action in circuit court to establish liability, recover damages for injury to natural resources, impose civil penalties, or seek an injunction.

* Instituting an administrative proceeding to establish liability, recover damages, or order corrective action.

* Assessing noncompliance fees for failure to abide by DEP rules or permit conditions.

* Pursuing damages, fines, or criminal penalties for violations.

Some municipalities have enforcement authority under local DEP authorized pollution control programs. Citizens may also sue to enforce environmental laws:

* Substantially affected residents of Florida may sue in circuit court to enforce agency action.

* Any citizen of Florida may bring an action for injunctive relief to compel DEP to enforce its rules or to enjoin anyone from violating any environmental laws.

The Enforcement Process

Initiation - DEP may learn of potential violations from reports by permit holders, self-reporting by law, or complaints from private citizens. DEP also has authority to enter and inspect private property to determine compliance with Departmental rules.

Once DEP determines that a violation has occurred, it has several options. The approach will depend on the severity of the alleged violation, the history of non-compliance and willingness to correct, and whether DEP plans to pursue civil penalties or injunctive relief.

DEP may seek a variety of remedies including compliance through a Consent Order or Notice of Violation, injunctions, costs and civil penalties, damages to natural resources, or criminal fines.

SUMMARY

Inappropriate application of fertilizers and pesticides, improper disposal and storage of agrichemicals and their containers and poor management of animal waste are among the major sources of groundwater contamination by agriculture. Thousands of wells are currently being tested in Florida with hundreds showing contamination with nitrates, ethylene dibromide, bromacil and others. While these wells are predominately shallow, many others are found in deep wells withdrawing water from confined aquifers. This problem is not unique to Florida.

Florida has enacted a number of laws, rules and programs aimed at protecting groundwater and correcting documented contamination problems. It is expected that a statewide groundwater monitoring rule will be established for the state's dairy farming industry in the near future.

FUTURE IMPLICATIONS OF THE CLEAN WATER ACT AND COASTAL ZONE MANAGEMENT ACT

Lynn R. Shuyler, PE
NPS Coordinator
EPA Chesapeake Bay Program
410 Severn Avenue
Annapolis, MD 21403

As EPA moves into it's third decade, Congress is working on Clean Water Act amendments again and the Coastal Zone Management Nonpoint Source (NPS) control programs is about to move from the program planning stage to the implementation phase in 1995. The results of these activities will change the way we all work with NPS problems.

During the early years, EPA focused on control of industrial point sources and the building of municipal waste water treatment systems. These point source control strategies have made remarkable progress in water pollution control over the last two decades. Even with the load reductions that have been accomplished with point sources, many of the Nation's waters still need further assistance to meet desired use goals. It is clear that nonpoint sources must be controlled if we are to enjoy the clean water that the leaders of this Nation envisioned decades ago when they put into place early water pollution control legislation.

Congress realizing the enormous impact of NPS activities on the coastal waters of the nation, passed the NPS Coastal Zone Management act in 1990. This act calls for the States to have legally enforceable management measures and these measures must be implemented on all land areas within coastal zone management area.

This is a much different way of addressing NPS problems than we have been using in the past. It does not allow targeting of sources or land areas. Water quality standards violations are not required before action must be taken. This program requires that all NPS activities have management measures applied to them. It does provide a level playing field for all land owners within the coastal zone area.

NEW LEGISLATION

Congress is considering amendments to the Clean Water Act as this is being written, therefore it would be foolish to speculate on what will be passed in the future. However, what is known, is that Congress is considering something for NPS, Section 319, that is similar to what was passed for the coastal zone areas. Some versions under consideration have enforceable management measures, but allow some form of targeting. Targeting could, for example, take place within a state by selecting watersheds for control, but targeting within the watershed would not be allowed.

All we know for sure is that Congress is working on a new version of the Clean Water Act and that they are very concerned about the control of NPS activities throughout the nation, not just in the coastal areas. We will work with the new legislation, just as we have with prior legislation and we will make it work to solve the NPS pollution problems of the Nation.

One last thought, it is far easier to prevent NPS pollution than it is to stop or control NPS pollution. Therefore, as we move through this excellent agenda, let us remember that most of the action taken to date regarding NPS control has been in a reactive mode. This has caused most of the regulations and laws to have a reactive tone, we must move away from this mode and get into a proactive mode. We can, if we wish, help craft future NPS programs that will ensure that NPS problems do not start. If this were done, the cost to society could be greatly reduced.

It has been a great pleasure to be here and help open this conference, I am looking forward to papers and the discussions that will follow.

FUTURE IMPLICATIONS OF THE CLEAN AIR ACT

Stan Meiburg
U.S. Environmental Protection Agency
1445 Ross Avenue
Dallas, TX 75202

The Clean Air Act Amendments (CAAA) of 1990, signed November 15, 1990 by President Bush, is a very comprehensive law containing 11 titles (800 pages). These 11 titles include: nonattainment area requirements for the six criteria pollutants (ozone, carbon monoxide, PM-10, sulfur dioxide, nitrogen dioxide and lead), mobile source requirements, air toxics requirements, an acid rain program, operating permits program, and stratospheric ozone program. The EPA is now in the middle of implementing the CAAA of 1990 through State Air Pollution Control Programs. And the Agricultural community has been, and will be, affected by the continuing implementation of the CAAA of 1990.

Our commitment is to work together with the States, Federal Agricultural Agencies, and Producers to explain the Clean Air Act's requirements and find constructive strategies for cleaner air.

Example 1: Our Region has worked closely with the Lubbock, Texas area regarding PM-10 air quality issues. Lubbock is located in a large agricultural area influenced by : high winds, erodible soils, regional dust storm events (i.e. dust from other counties or states), flat topography, few natural barriers and limited rainfall. Lubbock experienced exceedances of the 24-hour PM-10 standard before and during 1989. When the Clean Air Act was amended in 1990, EPA worked with the State of Texas and the City of Lubbock on whether or not Lubbock should be classified nonattainment for the PM-10 Standards. After a thorough review of the data and many discussions, the decision was made to not designate Lubbock as a PM-10 nonattainment area (but to keep Lubbock classified as "unclassifiable" regarding the PM-10 Standards). Shortly after this decision, a consortium was set up (SWEAPS = Soils, Wind Erosion, Agriculture and Particulate Studies) to more closely study PM-10 ambient air quality and its relationship with agricultural activities. This consortium involved the U.S. EPA Region 6, the SCS, USDA Agricultural Research Service in Big Spring, and many Texas agencies including the TNRCC and the Texas Department of Agriculture.

Example 2: EPA published an Alternate Control Techniques (ACT) document for control of VOC emissions from agricultural pesticide application in March, 1993. The Clean Air Act Amendments of 1990 required EPA to develop ACT documents for sources of VOCs and NOx that emit 25 tons per year or more. The pesticide application ACT:

1. Estimates nationwide VOC emissions associated with pesticide use.

2. Identifies control options.

3. Estimates environmental and cost impacts of control alternatives.

4. Serves as technical support for any state (e.g. Texas) that wants to control VOC emissions from pesticide use as part of an ozone control strategy.

In developing the ACT, EPA's Office of Air Quality Planning and Standards coordinated with the EPA Office of Pesticide Programs, the USDA, pesticide manufacturers and formulators, agricultural extension agents, equipment vendors, and universities conducting research on pesticide application and environmental fate modeling.

Example 3: The EPA announced on June 1 the establishment of standards designed to reduce exhaust emissions from diesel engines used in non-road equipment such as farm tractors, forklifts and road construction equipment. The rule will become effective in 1996 for all new non-road compression-ignition engines at or above 50 horsepower in size. These engines currently contribute over 9% of total national NO_x emissions from all sources, and 75% of all non-road NO_x emissions.

Example 4: CFC's and farm equipment. The regulations to implement Title VI, stratospheric ozone protection, should be particularly relevant to this audience which spends considerable time outdoors, working in the sun, exposed to the sun's ultraviolet rays. Depletion of the ozone layer allows increased amounts of ultraviolet radiation to reach the earth's surface. UV radiation is responsible for skin cancers, including the deadly melanoma, cataracts, and decrease in crop yields.

How do you keep cool while driving your tractor in the fields and still comply with the law? You may obtain a certification under §609. An approved certifying organization can send you the study materials in the mail, it is an open-book test, and if you pass, the certification will be sent to you. This will allow you to purchase the small cans of R-12. It is NOT against the law to top off your leaky system. We recommend that it be fixed but the law does not require it. If you decide to have it repaired, or have to replace the unit, the work must be done by a certified technician, which your farm equipment dealer undoubtedly has at his shop.

While the cab of your combine may only contain a small amount of refrigerant, motor vehicles and motor vehicle-like appliances, e.g., farm equipment, constitutes the largest source of CFC emissions into the atmosphere.

Example 5: Air Toxics (112(r)) provisions and agriculture

The Clean Air Act of 1990 established accidental release provisions under Section 112(r) in order to prevent catastrophic releases of gases, thus, preventing loss of life and harm to the environment.

Section 112(r) requires that a facility storing greater than a threshold quantity of any of approximately 162 chemicals and/or highly explosives must submit a risk management plan (RMP). The list was promulgated in January, 1994.

A Risk Management Plan rule was proposed in October, 1993 with a final rule expected in mid-1996.

A Risk Management Plan includes a hazard assessment, prevention program, and emergency response plan.

- The hazard assessment documents chemicals used and their toxicity.

- The prevention program requires a review of all processes in order to determine whether these processes are safe and accidental releases are prevented.

- The emergency response plan is needed to ensure safety of off-site inhabitants in case of accidental release.

Risk Management Plans are due within 3 years after promulgation of the final rule.

Farms are exempt from these requirements if ammonia is the only chemical stored.

However, Coops that store large quantities of ammonia are not exempt. The threshold for anhydrous ammonia is 10,000 lbs. and the threshold quantity for ammonia with concentration > 20% is 20,000 lbs.

A supplemental rule (to the risk management plan rule) is expected to be proposed in December, 1994 that will allow a tiered approach for implementing the risk management plan program. Some sources would have to meet minimal requirements, whereas, other source types would need to meet all requirements.

Facilities that are major sources under other parts of the Clean Air Act in addition to being subject to accidental release provisions will also be required to obtain an operating permit. If a facility is subject only to Section 112(r), then it does not need an operating permit.

IMPACT OF REGULATIONS AND LAWS PROMULGATED IN RESPONSE TO THE CHESAPEAKE BAY PROGRAM

Lynn R. Shuyler, PE
NPS Coordinator
EPA Chesapeake Bay Program
410 Severn Avenue
Annapolis, MD 21403

Chesapeake Bay is the largest and most productive estuary in the Nation. The Bay has been the subject of intensive research and implementation programs to control pollution loads for the past two decades. These early research studies resulted in the first Chesapeake Bay Agreement, signed in 1983 by Pennsylvania, Maryland, Virginia, the District of Columbia and EPA. This first agreement signaled the beginning of the cooperative effort to restore the living resources of the Bay. The research results did not pinpoint any one source of pollution as the major cause for the declining living resources in the Bay. Therefore, pollutants from all sources are targeted for reduction and both nitrogen and phosphorus are subject to controls.

The second Chesapeake Bay Agreement was signed in 1987. This agreement went much farther than just pledging to restore the living resources of the Bay, it set a number goals for the jurisdictions to accomplish. One such goal was the development of a basin wide nutrient reduction strategy to accomplish a 40 percent reduction of the 1985 controllable nitrogen and phosphorus loads to the Bay by the year 2000. The strategy also recognized that some nonpoint source (NPS) loads are not man induced, such as loads from mature forest lands.

LOADS IN THE CHESAPEAKE BASIN

To understand just how far reaching this strategy really is and the complexity of the nutrient control programs in the Bay, one has to understand the size of the drainage basin and the mix of land uses. The Chesapeake Bay drainage basin contains about 64 thousand square miles and drains part of six States and the District of Columbia. The Bay covers about five thousand square miles, bringing the total area to

69 thousand square miles. The Bay is highly impacted by the NPS loads, because it has more drainage area per unit volume of water than any other estuary. Table 1. provides a distribution of land uses for the Chesapeake Bay drainage basin that are used in the watershed model.

Table 1. Distribution of Land Use in the Chesapeake Basin

Land Use	Total Acreage	% of Total Basin
Cropland	8,237,391	20.00
Pasture	3,739,158	8.96
Forest	24,457,144	60.00
Urban	4,160,082	10.00
Water	526,115	1.00
Animal Waste	14,473	0.04

Source: Chesapeake Bay Program (1991)

Table 2. provides a summary of model simulated loads for total phosphorus and total nitrogen in the entire watershed. The summary data show that nonpoint sources (including animal wastes, cropland, pasture, urban, forest and atmospheric deposition), contribute 66 percent of the phosphorus and 77 percent of the nitrogen to the Bay; while point sources (primarily municipal wastewater treatment plants) contribute the difference (34 percent and 23 percent respectively).

Table 2. A Comparison of Phosphorus and Nitrogen Loadings From Nonpoint and Point Sources (million pounds/year based on 1985 land use)

	Phosphorus		Nitrogen	
	NPS	PS	NPS	PS
Farmland	10.56		126.63	
Animal Waste	2.96		19.32	
Forest	0.76		70.26	
Urban	2.15		32.71	
Atmo. to water	1.67		40.66	
Point Sources		9.15		86.82
Total	18.10	9.15	289.58	86.82

Source: Chesapeake Bay Program (1991)

CONTROL PROGRAMS

Both point and nonpoint sources have been high priority since the Bay Program started. NPS programs had to be greatly expanded, since they were not as fully developed as the point source programs. Early emphasis in the agricultural NPS programs was on the management of manure from animal production. Pennsylvania developed a manure management manual and required nutrient management plans for lands receiving manure if the farmer received state cost share assistance for the farm. Virginia and Maryland quickly followed suit, developing nutrient management programs of their own. All programs began by targeting land that received manure as a high priority, with nutrient management plans becoming a mandatory component of a manure management systems in all three States.

Urban NPS programs had begun developing sediment and erosion control regulations even before the Chesapeake Bay Program took shape in 1983. These programs are regulatory in nature and require permits for land development such as roads and urban construction. Other programs dealing with stormwater and installation of septic systems were in existence prior to 1983.

It is clear that many pollution control programs were in existence in the Basin to deal with NPS sources even before the implementation phase of the Chesapeake Bay Program began in 1984. However, many of these programs were not fully implemented or fully funded until after the Bay Program became active. Since the early 1980's the four jurisdictions have made major commitments to NPS control programs. As a result of the attention given to these programs, many changes have occurred at the local and county level regarding the way conservation assistance is given and what is required of a land owner who receives assistance. States have revisited the suite of practices which receive cost share funds and have focused more on water quality and nutrient reduction than ever before. States are providing staff and funding to conservation districts for additional technical assistance to ensure that plans are prepared and practices installed in a timely manner.

NEW LAWS AND REGULATIONS

There has not be a great flood of new laws or regulations as a result of the Chesapeake Bay Program. There has been some strengthening of existing laws and expansion of regulations to cover more sources.

Maryland recently passed a law requiring the certification of nutrient management planners working in the state. Working together through the Chesapeake Bay Program structure, the jurisdictions have established the technical specifications and standards for nutrient management plans for basin. Pennsylvania enacted a very strong manure management law requiring nutrient management plans for all farms which have an animal density of two or more animal units per acre. This law also requires the certification of nutrient management planners, similar to the Maryland law. Pennsylvania has indicated that implementation of this law will greatly reduce the nitrogen loads from these farms. The Virginia legislature passed a nutrient management certification law similar to the ones in Maryland and Pennsylvania. With a common set of standards and specification for nutrient management plans it should be possible, in the near future, for planners certified in one state to work in all three states and be able to satisfy the requirements of each state.

There are critical area laws and resultant regulations in both Maryland and Virginia which deal with lands near tidal waters and require implementation of conservation plans and/or the establishment of buffer strips along the edges of fields. These laws are mandatory for the lands they address.

All of these changes can be attributed to the Chesapeake Bay Program in some manner. However the real force in the Bay Program is the formal agreements and the strategies that are jointly developed by the partners in the program and signed by the Governors of each State, the Mayor of DC and the Administrator of EPA. These documents carry the force of an executive orders for the jurisdictions and tend to move programs and create actions without the need for formal legislation in many cases.

The 1992 amendment to the Basinwide Nutrient Reduction Strategy of 1988 is having a profound impact on everyone in the Basin. This amendment called for the development of tributary specific nutrient reduction strategies by each jurisdiction. These strategies layout in detail the actions and management measures that must be taken by both point and nonpoint sources to reach the reduction goals set out in the 1988 Basinwide Nutrient Reduction Strategy. The tributary strategies indicate the number of acres that must be treated by each control measure within a river basin. They also identify the point sources and the level of treatment each must implement. In some cases the level of implementation of a given NPS management practice may exceed eighty per cent of the acres available for the practice. Only time will tell if the tributary strategies can be fully implemented without the passage of laws making them mandatory and requiring implementation of all the management practices. It should be noted that the strategies have already made tradeoffs between point and nonpoint sources and are very close to utilizing maximum coverage of the land areas needing treatment. Therefore there is no magic action or formula that can be invoked if one segment of a tributary does not meet it's goal. The only real option would be to go to a regulatory strategy for implementation, much like the concept of the Coastal Zone Management Act NPS program.

RESULTS OF THESE ACTIONS

Nutrient loads to the Bay are being reduced from both point and nonpoint sources. The point sources have already reached their goal for phosphorus load reductions, thanks in large part to a phosphorus ban in detergents. NPS programs have made great progess in the past decade, but still have a long way to go and a very short time to complete the task. One encouraging note is that agriculture is beginning to realize the importance to reporting all the NPS control actions that have taken place in the basin. It appears that agriculture may have a very large portion of the crop land with some control measures in place at this time. However, many of these acres have never been reported in a manner that allows these acres to be used in the progress modeling that takes place every year. Once the tracking systems are able to account for all of the NPS control activities that are taking place in the basin, the Program will be able to get a more accurate account of the progress to date.

FUTURE ACTIONS

The 1992 Nutrient Reduction Strategy Amendment requires a re-evaluation of the progress being made toward the goal during 1997. Chesapeake Bay Program will use both the watershed and water quality models to assess the reduction progress as it takes place. At the same time the jurisdictions will need to evaluated their ability to reach the implementation goals in the tributary strategies. If they see that the tributary goals will not be reached by the year 2000, they will have to look at alternative ways to deliver the program to the people. The jurisdictions may move to more regulatory actions to ensure full implementation or some combination of regulation and voluntary actions to reach the goals. The States also, face the problem of maintaining the goals over time as population increases in the basin. This could be a far more difficult task than reaching the goal in the first place.

Each state has the opportunity to utilize the provisions of the NPS program under the Coastal Zone Management Act by implementing the program in July of 1995. This program would make management of nonpoint sources mandatory for the portion of the Chesapeake Bay basin which lies within the coastal zone management boundary.

I believe that the jurisdictions will make the necessary adjustments in the control programs and that they will reach the year 2000 nutrient reduction goals for the Chesapeake Bay.

REFERENCES

Chesapeake Bay Program. 1991. "1990 Progress Report for the Baywide Nutrient Reduction Strategy". Annapolis, MD.

HUMAN HEALTH CONCERNS IN LIVESTOCK AND POULTRY HOUSING

Jay D. Harmon, Ruihong Zhang, and Hongwei Xin
Assistant Professors
Agricultural and Biosystems Engineering Department
Iowa State University
Ames, IA 50011-3080

Air quality within livestock and poultry confinement housing has long been known to affect animal performance. The effect upon animals, while important, is mostly an economical, if not a moral, issue. The most costly effect associated with poor air quality is that being paid through poorer health of agricultural workers exposed to poor air quality.

The magnitude of the problem is probably quite large. Donham and Gustafson (1982) estimated that 700,000 persons in the United States are occupationally exposed to confinement livestock and poultry housing. A survey of 2459 Iowa livestock confinement workers showed that over 60 percent of those responding reported some type of adverse effect including cough, sore throat, runny nose, eye irritation, headaches, tightness of chest, and muscle aches and pains (Donham and Gustafson, 1982). The Federal Register (1992) stated that "..the illness incidence rate among agricultural workers for 1989, the latest year reported by the Bureau of Labor Statistics, was 45.5 per 10,000 full-time workers, higher than mining and construction." It continues, "In addition, these statistics are believed to underestimate agricultural morbidity by a large margin because OSHA does not require recordkeeping and reporting by farms with 10 or fewer employees and because workers' compensation laws in most states do not cover farms with few employees."

The objective of this paper is to give an overview of the human health hazards associated with confinement livestock and poultry facilities.

DEFINING THE ENVIRONMENT

The environment within livestock and poultry buildings contains many different potential hazards to the worker.

These include gaseous contaminants, such as ammonia and hydrogen sulfide, particulate contaminants (dust), excessive noise, substandard lighting, and physical hazards associated with animal interaction. While many hazards are obvious, the gaseous and particulate contaminants can be subtle and may slowly affect the agricultural worker.

Gaseous Contaminants

Dry outdoor air is approximately 78.09% nitrogen, 20.95% oxygen, 0.93% argon and 0.03% carbon dioxide, with slight traces of inert gases. Due to breakdown of animal manure, respiration of animals, and use of unvented heaters within the buildings, the environment develops into one that may be harmful to animals as well as agricultural workers. The physiology of animals, as well as waste handling systems and other housing characteristics make different gases critical depending on the animal type. Table 1 illustrates which gases may be associated with different types of animal housing. Gas sources and the relative effects on humans are summarized in the following sections.

Table 1. Relevant Gases in Different Housing Systems[a].

Gas	Poultry	Swine	Veal	Sheep	Cattle
NH_3	Yes	Yes	Yes	Yes	Yes
CO	Yes	Yes	Yes	Yes	Yes
CO_2	Yes	Yes	Yes	Yes	Yes
H_2S	only in buildings with liquid manure systems				
CH_4	only in buildings with liquid manure systems				

[a]Adapted from Mutel et al., (1986)

Ammonia: Ammonia is a pungent toxic gas that is detectable with the human nose even at low concentrations. It is released from fresh and decomposing manure, particularly in situations in which manure has a chance to dry. High temperatures promote its production, (DeBoer and Morrison, 1988). Ammonia is an irritant that inflames wet body tissues, such as the eyes and lungs, even at low concentrations. The physiological response of humans to ammonia begins with detectable odors at 5 to 50 ppm (DeBoer and Morrison, 1988). Irritation to mucous surfaces occurs at 100 to 500 ppm. Immediate irritation of eyes, nose and throat occurs at 400 to 700 ppm. Severe eye irritation, coughing and frothing at the mouth, which could be fatal, occur at 2000 to 3000 ppm. Respiratory spasm and rapid asphyxia may occur at 5000 ppm. It is rapidly fatal at 10,000 ppm.

Hydrogen Sulfide: Hydrogen sulfide is a toxic gas that is heavier than air. At low levels, it has a characteristic odor similar to rotten eggs. It is produced during anaerobic decomposition of manure and is therefore associated with deep pits. Dangerous levels of the gas may be present during agitation and pumping of deep manure pits. Twenty-four deaths related to hydrogen sulfide exposure occurred in the Midwest between 1984 and 1991 (Donham, 1991a). One possible reason that fatalities occur so often is that olfactory senses are paralyzed at high concentrations and so victims can not detect odors.

Hydrogen sulfide is classified as an irritant at sub-lethal levels. According to DeBoer and Morrison (1988), the least detectable odor occurs at 0.01 to 0.7 ppm. An offensive odor is detectable at 3 to 5 ppm with eye irritation at 10 ppm. Irritation to mucous membranes and lungs occurs at 20 ppm. Olfactory-nerve paralysis occurs at 150 ppm, followed by headaches, dizziness and nervous system depression at 200 ppm. Nausea, excitement, insomnia and death may occur after 30 minutes of exposure at 500 to 600 ppm. It is rapidly fatal at 700 to 2000 ppm.

Carbon Dioxide: Carbon dioxide in the normal atmosphere is approximately 300 ppm on a volummetric basis. It is produced primarily from respiration of animals with lesser amounts coming from decomposition of manure. Unvented heaters also add carbon dioxide to the interior atmosphere.

Carbon Dioxide can be classified as an asphyxiant in high enough concentrations. Levels of 20,000 ppm are safe with increased breathing rate occurring at 30,000 ppm. This is followed by drowsiness and headaches at 40,000 ppm and heavy breathing at 60,000 ppm. Violent panting occurs at 100,000 ppm. Potential fatality may occur after a few hours of exposure to 250,000 ppm or 30 minutes at 300,000 ppm.

Carbon Monoxide: Carbon monoxide could be a problem in situations where incomplete combustion is occurring in unvented propane or natural gas heaters, or from an internal combustion engine. During winter operation when buildings are using heaters and maintained with minimum ventilation this should be of special concern. The toxicity is caused by rapid absorption of carbon monoxide in blood and replacement of oxygen on hemoglobin cells. Because of this replacement, it takes time for recovery and repeated exposures of low concentrations may be harmful. Carson (1990) stated that sow exposure to carbon monoxide concentrations greater than 200 ppm may cause stillbirths.

Methane: Methane is an explosive gas. It is produced during anaerobic decomposition of manure and is highly flammable in concentrations above 5 to 15% by volume in air.

Measurement of Gases: DeBoer and Morrison (1988) quoted Donham as stating that there are several reasons why gas measurement might be useful. These include: 1) to assure good air quality during everyday operating procedures; 2) to document possibly harmful levels where human or animal health problems have been noted; 3)to assure that toxic gas levels are not rapidly rising when undertaking potentially dangerous tasks (e.g., agitation of liquid manure); 4) to investigate premises where losses of hogs due to building or ventilation malfunction may lead to suits against maufacturerers; and 5) to evaluate the effectiveness of building management procedures or retrofitted environmental control systems.

There are several types of gas measuring devices available. The most common for field measurement are detector or colorimetric tubes that are used with a hand-drawn air pump. The detector tubes (which cost approximately $4 each) are made of glass and are made gas specific. Sampling is done by breaking the ends of the glass tube and using the air sample pump to draw a sample through the tube. The medium within the tube will change colors and can then be read to indicate the level of gas concentration. Gas sample pumps are priced between $200 and $350 dollars. The detector tube method is an instantaneous reading method.

Dosimeter tubes may be used to develop an exposure history of a worker to a certain gas. They look like the detector tubes except they are used as a passive measurement over some period. They are worn on the lapel of a worker. The medium within the tube changes color to indicate the level of gas exposure. The reading is then divided by the number of hours of exposure to find the average worker exposure. The main disadvantage to the dosimeter tubes is that they are slow to react and are not a good warning system for lethal gas exposure. Dosimeter tubes are approximately $4 each.

Solid state electronic detectors are also available that are capable of continuously monitoring the environment. Many have an audible alarm built into the system. They are quite expensive with most costing more than $1000.

Particulate Contaminants

Particulate contaminants, or more commonly dusts, are not only a nuisance, but also can contribute to worker and animal health problems. According to Donham (1986), dusts may be composed of dried fecal material, feed, animal dander, feathers, mold, pollen, grain mites, mineral ash, gram-negative bacteria, endotoxin, microbial proteases, ammonia adsorbed particles and infectious agents. Feddes et al. (1992) stated that in turkey housing studies, airborne respirable particles were primarily fecal material.

Particles are classified according to size. Particles larger than 10 μm usually settle out of the air rapidly (DeBoer and Morrison, 1988). If they are inhaled, they are trapped by moist tissue in the nose and throat. They may cause irritation of the nose and throat and cause sneezing. Particles 5 to 10 μm in size will reach the windpipe causing irritation of the lining and possible infection. Particles less than 5 μm, called respirable particles, may reach the bronchioles and alveoli, and therefore present the most hazard.

Dusts adversely effect health by directly irritating tissue and by causing allergic reactions in response to inhaled foreign particles. It also transports embedded microorganisms and adsorbed gases deep into the sensitive tissue of the lungs. Endotoxin is of particular concern to agricultural workers. It is a substance found in the cell wall of Gram-negative bacteria and has a high biological potency. It has been linked with respiratory symptoms in workers.

Measurement of Particulates: Dust can be sampled in many ways. One of the most common is to use a small air sample pump to draw air through a filter at the rate of 1.7 to 1.9 l/min. The filter is then weighed and the sample weight is divided by the total flow (rate times time) to get the particulate concentration in g/l. To measure only the respirable fraction, a cyclone is used to separate out large particles before they get to the filter. Other methods of dust collection include thermal precipitation, sedimentation, impaction, optical counters and electrostatic precipitation.

Bioaerosol measurement is more difficult. Bacteria and molds are generally collected using impaction samplers into solid culture medium. Medium is then cultured and colony forming units (cfu) are counted. Viruses are generally collected in liquid medium and inoculated into tissue cultures. Endotoxin analysis has been performed by taking dust samples and assaying them by using Limulus amoebocyte lysate (LAL) assay. Commercial test kits are then used for checking the assay (Feddes et al.,1992). Endotoxin is believed to reside predominantly in the respirable fraction (DeBoer and Morrison, 1988).

HEALTH IMPLICATIONS

Worker health implications in swine housing has received a great deal of attention in the past. Donham, et al.(1984) surveyed swine confinement producers and non-confinement workers for chronic respiratory disease symptoms. The comparison of the two groups is shown in Table 2. They concluded that confinement workers experienced significantly higher prevalence of chronic bronchitis and wheezing (odds ratio 7 and 4, respectively). Whyte et al. (1993) stated that 10% of United Kingdom poultry stockmen had respiratory impairment and that layer stockmen were exposed to more hazardous environments due to the practice of "blowing out" cages with compressed air. Twenty percent of the farms in their study exceeded the standard for dust exposure in the UK by 2.5 times.

Table 2. Chronic Respiratory Disease Symptoms (Donham, et al., 1984)

Symptoms	Confinement Swine Producers N=24	Nonconfinement Swine Producers N=24
Chronic Cough	33%	8.3%
Chronic Phlegm	58%	21.0%
Chronic Episodic cough with phlegm	29.2%	4.2%
Chronic Wheezing occasionally apart from a cold	62.5%	29.2%
Chronic Wheezing most days or nights	4.2%	4.2%
Shortness of Breath	20.8%	20.8%
Frequent Chest Colds	45.8%	20.8%
Off Work with Chest Illness	8.3%	0

Donham (1991b) listed 10 conditions that swine producers experience as a result of exposure to harsh environments in confinement buildings. They are listed below:

Hydrogen sulfide poisoning: This occurs only in facilities that have liquid manure storage and is of great concern during liquid manure agitation. Levels of 400 ppm will cause poisoning.

Bronchitis: Cough and coughing up phlegm are most common complaints. It is considered chronic if it occurs for 3 or more months per year for 3 years. Twenty to 60% of swine producers have this condition with an additional 30% having an acute case. Long term irritation causes deterioration of the airway linings. Cells produce extra mucous and cilia do not work properly, therefore particulate removal is less effective. Particles can only be removed by coughing up phlegm.

Hyperactive airways disease: Tightness of chest and wheezing are the main symptoms. Muscle cells in the airway become inflamed and enlarged, and will constrict upon almost any irritation thereby causing the airways to become narrower. This condition is seen in 20 to 30% of the swine producers.

Atopic asthma: Wheezing caused by an allergic reaction occurs within a few minutes of exposure. Less than 5% of swine farmers experience this.

Acute organic dust toxic syndrome: Symptoms include fever and flu-like illness with headaches, muscle pains and chest tightness. Thirty to 40% have had episodes. This is attributed to some activity that exposes the producer to dust, (such as moving hogs or catching chickens) and it begins 2 to 6 hours after exposure. Endotoxin exposure is felt to be the toxicant.

Chronic organic dust syndrome: Symptoms include chronic tiredness, muscle aches and pains, and chronic shortness of breath. With proper protection they get better. Symptoms are related to long term lower exposures to the confinement environment. Endotoxins are a suspected cause.

Mucous membrane irritation: Symptoms include sore throat, irritation of the eyes, nose and sinuses. Thirty to 50% of swine producers experience this.

Increased susceptibility to other chest illnesses: Symptoms include frequent colds and pneumonia. Twenty to 30% report this condition.

Chronic sinusitis: Dizziness, chronic cold, and ears popping are prime symptoms. Twenty to 40% of swine producers experience this.

Byssinosis-like condition: The person experiences increased symptoms of cough and chest tightness after several days away from the confinement house.

In addition Mutel et al. (1986) reported that respiratory infectious diseases are another potential hazard. These include Newcastle disease in poultry confinement, Q fever from situations which call for assisted animal births and swine influenza. In addition, DeBoer and Morrison (1988) name tuberculosis, anthrax, brucellosis, leptospirosis, salmonella, streptococcus, staphylococcus and viral or fungal infections as other possible hazards.

REGULATIONS

In 1992, the Federal Register (1992) detailed a proposal to set permissible exposure limits for agricultural workers. Farming operations that do not maintain a temporary labor camp and that employ 10 or fewer employees were exempt from OSHA regulations. The proposal did however state that "Swine and poultry confinement buildings are sources of especially high exposures". The new section for agriculture of 29 CFR was to be numbered 1928.1000 and included approximately 220 substances that had unestablished exposure limits previously.

Regulations are generally set at a level at which few workers will show adverse effects with repeated exposure. Federal Register (1992) defined the following terms that are used to quantify the environment of the worker.

<u>Time Weighted Average (TWA):</u> is the employee's average airborne exposure in any 8 hour work shift of a 40 hour work week. Concentrations are set to which nearly all workers may be repeatedly exposed without adverse effects.

<u>Short Term Exposure Limit (STEL):</u> is the employee's 15-minute timeweighted average exposure which shall not be exceeded at any time during a work day. DeBoer and Morrison (1988) state that these are set at concentrations to which workers can be exposed continuously for a short period of time without suffering from irritation, chronic or irreversible tissue damage, or narcosis which may increase the likelihood of accidental injury, impair self-rescue, or materially reduce work efficiency.

<u>Ceiling:</u> is the employee's exposure which shall not be exceeded during any part of the work day. If instantaneous monitoring is not feasible, the ceiling shall be assessed as a 15-minute time weighted average exposure which shall not be exceeded at any time over a working day. This concentration level should not be exceeded even instantaneously due to fast acting physical impairments that may occur.

Table 3 contains the proposed values for agriculture contained in 29 CFR 1928.1000. Values for other occupations from the American Conference of Governmental Industrial Hygienists (ACGIH) are shown for comparison.

Table 3. Pertinent Permissible Exposure Limits in ppm

Substance	Proposed[a] TWA	Proposed[a] STEL	Proposed[a] Ceiling	ACGIH[b] TWA	ACGIH[b] STEL
Ammonia	-	35	-	25	35
Carbon Dioxide	10,000	30,000	-	5000	30,000
Carbon Monoxide	35	-	200	50	400
Hydrogen Sulfide	10	15	-	10	15
Particulates (mg/m^3)					
Total Dust	15	-	-	10	-
Respirable	5	-	-	-	-

[a]Federal Register (1992).
[b]ILO (1991).

Another important aspect of the proposed regulation was the way in which exposure to multiple substances were handled. A worker's measured TWA values for each substance was divided by the permissible exposure limit for that substance. This is done for each substance to which a worker is exposed . These numbers are then summed and must be less than one in order to comply with the regulations.

Currently, 29 CFR 1928.1000 has not been adopted and appears to be vacated due to lawsuits contesting the process of establishing levels. However, it is important to note that they were proposed and because other working environments must adhere to similar standards, agriculture is vulnerable. If workers are adversely affected by exposure within confinement facilities and choose to take legal action against an employer, the lack of a standard will not prevent them from prevailing. This is an issue on farms of all sizes. It is a high probability that at least certain substances will be reproposed. There is also a probability that the 10 employee exclusion rider will be amended.

No attention was given bioaerosols in the proposed standard. Donham(1991a) proposed exposure thresholds in swine buildings noting that contaminants in excess of values in Table 4 were associated with a higher proportion of work related or swine disease or lower production parameters.

Ammonia levels in poultry and swine housing, as well as dust levels, can and often do exceed the total permissible exposure limits set by ACGIH. Heber _et al_.(1988) found dust in swine finishing units to average 8.1 mg/m^3, while Donham _et al_. (1977) found levels of ammonia and hydrogen sulfide in the winter to run as high 200 ppm and 10 ppm, respectively. Janni _et al_. (1984) stated that ammonia in turkey facilities regularly exceeds 50 ppm and it is not uncommon for it to reach 100 ppm.

Table 4. Proposed Exposure Thresholds (Donham, 1991a)

Substance	Human Health	Swine Health
Total Dust mg/m3		
area sampling	2.4	3.7
Respirable dust mg/m3		
area sampling	0.23	0.23
Endotoxin g/m3		
area sampling (total)	0.08	0.15
Carbon Dioxide ppm	1540	1540
Ammonia ppm	7.0	11.0
Total microbes cfu/m3	430,000	430,000

Many methods have been proposed for cleaning the environment of confinement buildings. Bundy and Hoff (1992) at Iowa State University have developed an electrostatic precipitator system that has shown promise. The discussion of other technologies is beyond the scope of this paper but they include, but are not limited to: fogging, vacuum cleaning, ionization, oil spraying, litter/manure management, feed additives, and specialized design and management of confinement buildings.

SUMMARY

The effects on the animal performance have always been of great concern to the producer. Human exposure, while not as continuous as that of the animals, is intense enough to cause serious health problems. Donham (1991a) stated that two hours of exposure per day for 6 years is enough to cause a serious problem. With this in mind, livestock and poultry confinement workers should be made aware of how serious the health effects can be so measures can be taken to decrease the risks. This can be done by wearing protective breathing apparatus, especially during dusty activities such as catching birds or moving swine. (However a self-contained breathing apparatus is required for exposure to excessive hydrogen sulfide.) Reduction of risks can also be taken by using proper ventilation and attention to details such as feeding operations and manure management. There is no easy way to avoid risks in confinement housing, but it can be minimized. Future regulation may not only make it a wise practice, but also a required one.

REFERENCES

Bundy, D.S. and S.J. Hoff. 1992. Development and Testing of a Particulate and Viable Aerosol Removal System for Livestock Housing. IN: International Conference on Agriculture Engineering. Swedish Institute of Agricultural Engineering. Uppsala, Sweden. June 1-4, 1992. pp. 149-150.

Carson, T.L. 1990. Carbon Monoxide - Induced Stillbirth. IN: Laboratory Diagnosis of Livestock Abortion. Iowa State University Press, Ames, IA 50011. Third Edition. pp. 186-189.

DeBoer, S. and W.D. Morrison. 1988. The Effects of the Quality of the Environment in Livestock Buildings on the Productivity of Swine and Safety of Humans, A Literature Review. University of Guelph, Guelph, Ontario, Canada, N1G 2W1.

Donham, K.J. 1986. Hazardous agents in agricultural dusts and methods of evaluation. Am. J. Ind. Med. 10:205-220.

Donham, K.J. 1991a. Human Health Risks from the Livestock Environment. IN:The Livestock Industry and the Environment. Iowa State University, Ames, IA. 50011. pp 13-27.

Donham, K.J. 1991b. Health Concerns from the Air Environmental in Intensive Swine Housing: Where Have We Come From and Where are We Going? IN: Making Swine Buildings a Safer Place to Work. National Pork Producer Council, Des Moines, IA 50306.

Donham, K.J. and K.E. Gustafson. 1982. Human occupational hazards from swine confinement. Ann. Am. Conf. Governmental Ind. Hyg. 2:137-142.

Donham, K.J., M. Rubino, T.D. Thedell and J. Kammermeyer. 1977. Potential Health Hazards to Agricultural Workers in Swine Confinement Buildings. Journal of Occupational Medicine 19(6):383-387.

Donham, K.J., D.C. Zavala, and J.A. Merchant. 1984. Respiratory Symptoms and Lung Function among Workers in Swine Confinement Buildings: A Cross-Sectional Epidemiology Study. Archives of Environmental Health 39(2):96-101.

Feddes, J.J.R., H. Cook, and M.J. Zuidhof. 1992. Characterization of airborne dust particles in turkey housing. Canadian Agricultural Engineering 34(3):273-280.

Federal Register. 1992. Air Contaminants; Proposed Rule. Department of Labor, Occupational Safety and Health Administration. 29 CFR Part 1910, et al. 6-12-92. Vol 57 No. 114, Book 2, Pages 26001-26602. United States Printing Office, Washington, D.C. 20402.

Heber, A.J., M. Stroik, J.L. Nelssen and D.A. Nichols. 1988. Influence of Environmental Factors on Concentrations and Inorganic Content of Aerial Dust in Swine Finishing Buildings. Trans. of the ASAE 8(5):875-881.

ILO. 1991. Occupational Exposure Limits for Airborne Toxic Substances: Values of Selected Countries. Occupational Safety and Health Series No. 37. International Labour Office, Geneva. Third Edition. pp.455.

Janni, K.A., P.T. Redig, J. Newman, and J. Mulhausen. 1984. Respirable Aerosol Concentrations in Turkey Grower Buildings. ASAE Paper 84-4522. ASAE, St. Joseph, MI.

Mutel, C.F., K.J. Donham, J.A. Merchant, C.P. Redshaw, and S.D. Starr. 1986. Livestock Confinement Dusts and Gases. Unit 4 of the Agricultural Respiratory Hazards Education Series. Iowa State University Extension, Ames, IA 50011.

Whyte, R.T., P.A.M. Williamson, and J.Lacey. 1993. Air Pollutant Burdens and Respiratory Impairment of Poultry House Stockmen. IN: Livestock Environment IV. Fourth International Symposium, University of Warwick, Coventry, England. ASAE, St. Joseph, MI. pp.709-717.

EPA'S EMPHASIS ON POLLUTION PREVENTION VS. REGULATION

Harry W. Wells, Jr.
Agriculture Coordinator, Pollution Prevention Division
U.S. Environmental Protection Agency MC-7409
401 M Street, SW
Washington, D.C. 20460

COMMENTS ARE STRICTLY THE OPINION OF THE AUTHOR, AND MAY OR MAY NOT REFLECT U.S. ENVIRONMENTAL PROTECTION AGENCY POSITIONS OR POLICY.

The title of these remarks "EPA's Emphasis on Pollution Prevention vs. Regulation" suggests that it is one or the other... it is not one or the other rather it is both. EPA does have a policy that prevention is the principle of first choice in all of its activities, both regulatory and voluntary. EPA is required under law to enforce the provisions of the Clean Water Act, the Clean Air Act, FIFRA, and other environmental statues. These statutory requirements remain undiminished by our emphasis on prevention and in fact, EPA is now seeking to integrate pollution prevention into regulatory approaches. The fact that prevention evolved at all is perhaps testimony to the thesis that there are limits to what can be achieved by regulatory approaches alone. What has evolved is a more balanced approach toward environmental stewardship - one that establishes a hierarchy of steps to prevent environmental contamination. It submit that this is particularly true when it comes to some types of agricultural enterprises. Pollution prevention in agriculture is often very complex and very difficult to achieve Today, I want to try to connect the theme of prevention to the poultry industry, look into the future and suggest ways that you as growers and vertical integrators can expand on some of the things you have already been doing.

I should state at the beginning that you as an industry have been working on issues of environmentally sound utilization of manure and dead birds for ears, and in a majority of instances have done so successfully. You are well aware of the nutrient and soil amendment value of composted or raw manure or pelletized manure and the value of rendering birds into feed and other by-products. In short this is not new to you, but I hope to make the case that you should be ready for future changes in animal agriculture by being even more pro-active about prevention.

The afternoon I will:

- Give you an overview of what pollution prevention means in EPA and how it is applied.

- Discuss the structure of agriculture...particularly animal agriculture and suggest what might be on the horizon.

- Offer thoughts on how both the growers and the vertical integrators stay ahead of the regulators by crafting win-win scenarios for profit and for environmental quality.

POLLUTION PREVENTION

EPA's pollution prevention program was initiated in the late 1980's. It is not a new idea. It evolved largely because traditional pollution control and cleanup approaches simply did not go far enough. The Agency policy was formalized into National policy with the passage of the Pollution Prevention Act of 1990. In that Act, the following hierarchy was established:

Source reduction:	Pollution should be prevented or reduced at the source wherever feasible.
Recycling:	Pollution that cannot be prevented should be recycled in an environmentally safe manner.
Treatment:	Pollution that cannot be prevented or recycled should be treated in an environmentally safe manner whenever feasible.
Disposal:	Disposal or other release into the environment should be employed as a last resort and should be conducted in an environmentally safe manner.

I might add at this point that despite what man of you may believe, most EPA bureaucrats do not live to regulate poultry operations. EPA has historically been an agency that focused most of its energies on point sources of pollution---end of pipe controls for industry, pesticides and chemicals. Agriculture and particularly prevention of pollution from agricultural sources is not the first thing the average EPA bureaucrat things about This is the good news for you today. The bad news is that I believe this will change as the nature of agricultural production changes. How the poultry industry is able to cope with that change is up to you. More on that later.

Getting back to prevention, I would add that despite EPA's significant successes in cleaning the nation's water bodies, largely at point sources under the NPDES permit process we have still not universally achieved the water quality goals that were originally envisioned in the Clean Water Act. We now have an additional tool or approach which is pollution prevention. Remember too that prevention as we know it today is almost exclusively voluntary. You can either circle the wagons and wait for the enforcement people or you can address problem areas head on with solution sets. I submit that the latter makes the most sense.

EPA's Prevention Approach

It is important to recognize that the pollution prevention theme is supported at the highest levels of EPA and in President Clinton's administration.

- During her earth day speech in June 1993 and in a subsequent policy statement, EPA Administrator Carol Browner identified prevention as the **"principle of first choice" and the new "central environmental ethic" for all EPA's programs** and activities.

- The President in June 1993 convened the Council on Sustainable Development, a blue-ribbon panel of industry, government and environmental leaders to develop a national strategy on issues such as sustainable agriculture and land use, environmental justice and "green" manufacturing.

- The Agency, in response to Vice President Gore's **National Performance Review**, released in September 1993, has accelerated its efforts to integrate pollution prevention into all regulations, policy and guidance.

Seven Themes Characterize EPA's Pollution Prevention Activities

1. Incorporate prevention as the principle of first choice into the mainstream work of the agency.

   - The Common Sense Initiative focuses on pilot industry sectors. Targeted industries will be selected from traditional manufacturing industries such as petroleum refining, iron and steel fabrication and electronics. There is not an agricultural "sector" anticipated at this time but I urge you to not wait for EPA to come to you - engage us in the prevention debate now.

- Regulation - EPA's new regulatory Action Development Process and its Source Reduction Review Project target key air water and solid waste rule makings for multimedia pollution prevention action.

- Enforcement - EPA's new Office of Enforcement and Compliance Assurance promotes pollution prevention through innovative compliance projects and supplemental environmental projects in combination with traditional fines and penalties. Again for both regulation and enforcement, it is better to be discussing prevention actions - both for individual growers and for vertical integrators now than after there is a problem.

2. Help build and facilitate a national network of prevention programs particularly among states and local governments.

- Pollution Prevention Incentives for States (PPIS). EPA regions provide about $6-8 million annually through the PPIS grants to help develop and sustain state Pollution prevention program activities The only agricultural PPIS grant activities that I am aware of focus on agriculture pesticide use reduction, irrigation and management of N and P in row crop production. There are no poultry waste programs that I am aware of in the PPIS Program.

- Technical Assistance/Transfer - EPA directs the national Pollution Prevention Information Clearinghouse (PPIC) to share pollution prevention information, cause studies and technologies and is working to establish new agreements with public health officials and physicians to increase pollution and disease prevention.

- Prevention and Pubic Health - This one is a sleeper until there is a public health problem. I need not remind you public health concerns...and I mean food safety...will galvanize both the public and governments overnight. Perhaps the best of all illustrations of the values of prevention.

3. Identify and pioneer new environmental programs - again, wearing my prophet hat, animal agriculture is not a large blip on the EPA radar screen now but it can be.

4. Establish new federal partnerships - here we have some successes and some failures. First the successes:

   - The President has signed new executive orders that require federal facilities to report wastes and emissions to take leadership in recycling and with new guidance from EPA on procuring "environmentally preferable products." Maybe someday the Federal government will only buy "green chickens". Who knows - we now have a policy that states that nearly one third of the gasoline sold in the most polluted U.S. cities must contain additives, such as grain alcohol, that are derived from corn or other renewable sources.

   - The failure is that a joint EPA-USDA pollution prevention strategy which was about to be unveiled was put on hold around the first of the year. This was unfortunate for a number of reasons:

     - The momentum and support developed over two years at the staff level in both EPA and USDA has diminished.

     - Animal waste management was targeted as prime for voluntary opportunities and prime for funding and demonstrations.

     - Major shifts in USDA budgets were anticipated to support the voluntary initiatives.

   Again the poultry industry has an opportunity to demonstrate leadership by crafting area wide or even watershed based approaches to manure management before water quality problems occur.

5. Generate and share environmental information to promote prevention, and track progress. Examples include:

   - The Toxic Release Inventory that documents the voluntary reductions in the releases of 17 priority toxic chemicals targeted under the voluntary 33/50 project.

- o Environmental marketing/eco labeling - EPA, through research and outreach is informing the debate on ways to provide better environmental information on products to consumers.

6. Develop partnerships in technological innovation with the private sector.

   - o So far these partnerships have been industrial. However there is no reason that the partnerships can not expand to agriculture.

7. Seek changes in Federal environmental law to encourage source reduction.

   - o EPA is advising Congress on how some of the Nation's environmental laws, such as the Clean Water Act and the Toxic Substances Control Act, night incorporate more preventive approaches. Again opportunities abound for leading with prevention initiatives on both the part of producers and vertical integrators.

STRUCTURE OF AGRICULTURE AND WHY THE CONCENTRATION TRENDS ARE IMPORTANT TO THE POULTRY INDUSTRY

The poultry industry pioneered and refined the techniques of concentration and specialization. Each of you is a part of this shift introduction practices. The trend of regional processing centers and contract growers with strict quality standards and controls of the final product is being copied by other food industries. As you well know the "other white meat" is specializing with large confinement operations. In the dairy business, it is not uncommon in some parts of the country to have 5,000 cow confined herds. In short, your production successes are being copied.

These trends may be inevitable and they may even be environmentally beneficial but one thing is certain. At some point in the future the public will discover that the myth of the independent-diversified farmer is long gone or limited to niche markets. Food production then is basically one more industry. The point is that you will be thought of as industrial processors - and indistinguishable from pulp and paper manufacturers, from iron and steel or electroplaters. The perceived thin veil of protection from government regulation afforded to the independent farmers in the 1950's will be lost. I am talking about public perception...not necessarily fact.

Others have forecasted similar changes in attitudes. In a survey of experts in the food and agriculture system conducted by the Rural Development Institute at the University of Wisconsin six emerging trends were identified that would shape the industry in the coming decades:

- Agricultural production will increasingly be influenced by public concern about environmental quality;
- Biotechnology will become integral to agricultural production as a means of reducing chemical input use;
- Vertical coordination will be increasingly common in the food and agriculture system;
- Agriculture will face more costly water because more clean water will be bid away by other uses;
- The urban and suburban portions of the population will have increasing political clout; and
- Policies and regulations designed to address serious threats to environmental quality will increasingly change the nature of the agricultural production system.

These forecasts pose key questions including:

What does all of this mean to EPA, and
What can the poultry industry do?

WHAT DOES THIS MEAN TO EPA?

To EPA the future scenario means that concentrated production facilities, be they swine, poultry, or dairy will increasingly concentrate animal manure. As the trend progresses, land applied manure may contribute to increased levels of polluted water - which is illegal under the Clean Water Act. According to EPA's Office of Water, "Nutrient runoff and leaching from animal waste has already impaired fisheries in 60,000 stream miles, caused extensive fish-kills in California and Florida, and contaminated ground water in 17 states." It means that a class of environmental problems exists and that there is a strong potential for the problems to increase over time. It means also that **now** is the time to craft prevention scenarios. Remember - EPA's principle for first choice is prevention.

EPA's Office of Water has a new initiative that is targeting runoff from concentrated animal feeding operations (CAFOs) -- large facilities that include chicken, dairy, swine and beef operations. While no firm monitoring data on DAFO pollution exists, EPA will push to include pollution from CAFOs in the 1993-1994 reporting cycle of 305 (b) reports to Congress. I se this as an opportunity for animal agriculture to voluntary adopt pollution prevention measures.

WHAT CAN THE POULTRY INDUSTRY DO?

Develop Partnerships with Government

Basically get on the prevention offensive now. Use your contacts with local state governments and the Federal government to initiate creative prevention programs. Do not circle the wagons and blame the corn growers or suburban chem-lawns for nitrate contamination of ground water. Just do it. I believe that there are compelling reasons for you to step out smartly with prevention programs. The following tenets seem to be common themes of successful prevention programs:

- Watersheds
- Aquatic Ecosystem Protection
- Measurable Results

Watersheds are manageable sized units of real estate for most people. People support and get behind projects and causes that are closer to home. If you suspect that there is a potential for contamination, take the high road to prevent the potential from becoming reality. If a watershed is presently polluted and your operation could be a contributor - take the high road to join with others in the restoration.

Aquatic Ecosystem Protection sounds complicated but it is not. Aquatic systems are both indicators of a broader ecological condition and things that people care about including fishing and swimming. It is also required under the Clean Water Act.

Measurable results must be a concept of any prevention activity. it means that we need to now what the baseline condition is and how it has changed over time as a result of actions being taken. is the watershed in better condition as a result of the actin being taken or not.

BRING US YOUR PARTNERSHIP IDEAS TO EXPLORE

You know the poultry industry better than anyone. You know what the limitations are and what the barriers are to managing poultry manure and bird mortality. You also know that the problems are only going to get worse and the potential for regulatory conflict will become greater over time. Market your prevention ideas with the same vigor that you market your birds. Consider looking again at concepts including:

- Utilization of pelletized poultry manure as a source of N for corn with transportation via the empty cars that delivered your feed. This has been talked about and the parts have never come together - why? Who are the winners or losers in such a partnership?

- What factors determine where new processing plants will be built. it is the availability of labor, the availability of crops to utilize the manure that will be generated, water quality, environmental regulations, soil types, access to consumer markets? Should the equation consider proximity to the horticultural industry that can use the heat generated from composting processes and the finished compost.

There are lots of ideas out there and some can work with the right incentives and mix of partners. I think that you will find a very receptive audience, when you put your knowledge of the industry to work for prevention.

ENVIRONMENTAL REGULATION AFFECTING POULTRY PRODUCTION IN EUROPE

R. J. Nicholson
ADAS Arable Research Centre
Anstey Hall
Maris Lane
Trumpington
Cambridge, CB2 2LK, England

M. de Bode
IKC
POSTBUS 56
7360 AB Beekberhen
Netherlands

The possible adverse environmental effects of livestock production have been a concern in many European countries since the mid 1970's. Concerns initially related to water pollution and odors but more recently include missions of ammonia and greenhouse gases. Most countries have therefore developed controls which relate to livestock production.

LEVELS OF REGULATION

Regulations exists at three levels:

1. European Union (EU) - formerly European Community (EC) - Directives, which set a framework for member country's regulations.

2. Individual countries have their own statutory controls.

3. Within countries, individual districts may impost local controls.

Legislation is enforced by a wide variety of agencies at national and local level. UK legislation is enforced at national level by government departments, agencies and other public bodies, and at local level by local authorities.

Some countries (UK and Germany) also have Codes of Good Agricultural Practice in addition to statutory controls. In

England and Wales, three separate codes have been produced relating to protection of water, air and soil. These give practical guidance to farmers on good practice and on compliance with legislation (MAFF 1991, 1992, 1993).

National and local legislation has developed according to livestock density, the pattern and intensity of agriculture, the physical environment, economic factors and political factors, in individual countries (Baldock & Bennett, 1991). In the Netherlands, which has Europe's most intensive agriculture, regulations relating to livestock production are necessarily more severe than in most other European countries.

Legislation is therefore diverse and complex. The majority applies to all types of livestock production, though specific parameters may be given for poultry. This paper does not, therefore, claim to be comprehensive. It outlines the main principles of legislation and gives specific examples of the more sophisticated controls applying to individual operational areas, such as buildings, manure storage and land application of manures.

AIMS OF REGULATION

The majority of relevant legislation is aimed at controlling certain operations so as to minimize harmful effects on the environment. Such regulations may be targeted at reducing water, air or soil pollution occurring via a number of routes as shown below in Figure 1.

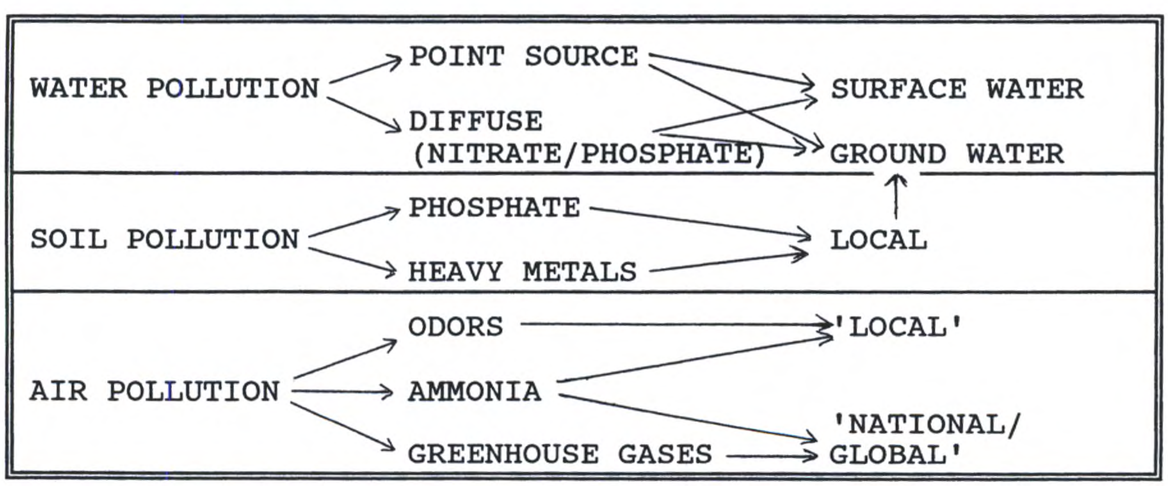


FIGURE 1

European Union member countries have generally adopted the 'Polluter Pays' principle in terms of who bears the cost of environmental legislation. Whilst this is still broadly the case for agriculture, countries such as the UK, Netherlands, Denmark and Germany have subsidized the cost of environmental measures undertaken by farmers, by grants to improve waste handling and storage facilities (Baldock & Bennet, 1991).

REGULATIONS GOVERNING BUILDINGS TO HOUSE POULTRY

These regulations can relate to water or air pollution, or the overall environmental effects (including visual appearance) of a production unit.

Permits/Licenses

In the Netherlands, Belgium, Denmark, Germany and France, a license or permit is needed if livestock are kept in large intensive units. In Belgium, operating permits carry an annual charge, which escalates for units above 30,000 birds. In the Netherlands one of the license conditions relates to calculated ammonia emission.

Environmental Assessments

EC Directive 85/337/EEC (EC, 1983) sets down a framework which requires member states to request an environmental assessment to be carried out before consent is given for certain major projects to be undertaken. These projects include roads, power stations, oil refineries, waste disposal installations and certain agricultural operations. Poultry rearing installations are included. An environmental assessment has to cover all likely environmental affects of new project, including flora, fauna, soil, water, air, landscape and outline measures to be taken to reduce any significant environmental effects.

In the UK, the Department of Environment requires a full environmental assessment to be carried out where a new system is to house over 100,000 broilers or over 50,000 layers. In Belgium, an Environmental Assessment is required for units over 20,000 birds in non-agricultural areas.

Planning Laws

Laws allowing development of new buildings vary greatly from country to country, and are normally enforced on a local basis. They may relate to the overall environmental effects and visual appearance of the proposed installation, and often include measures to minimize potential odor nuisance, or to ensure that adequate land area exists for manure disposal. This is often based on manure nitrogen loading.

In the Netherlands, each holding was given "manure production rights" in 1987, based on phosphate production. This mechanism is used to control new developments, or expansion of existing enterprises in "surplus areas", where average phosphate production exceeds 125 kg/ha.

Odors - Separation Distance

In the UK, farmers are required to notify the local planning authority of any new livestock building and formally apply for planning permission where an installation is within 400 m of residential houses, hospitals, schools, etc. MAFF's Code of Good Agricultural Practice for Protection of Air (Maff, 1992) describes factors likely to affect or reduce odor nuisance. Prescriptive definitions of separation distance are purposely avoided.

In the Netherlands and Germany however, guidelines have been developed which relate the numbers of livestock in a proposed unit to the minimum distance ("Cordon Sanitaire") which will be allowed between it and various types of domestic dwelling. The method may also incorporate a points system relating to the type of housing facility (Paduch, 1987). Distances varying from 100 m to 700 m may be required.

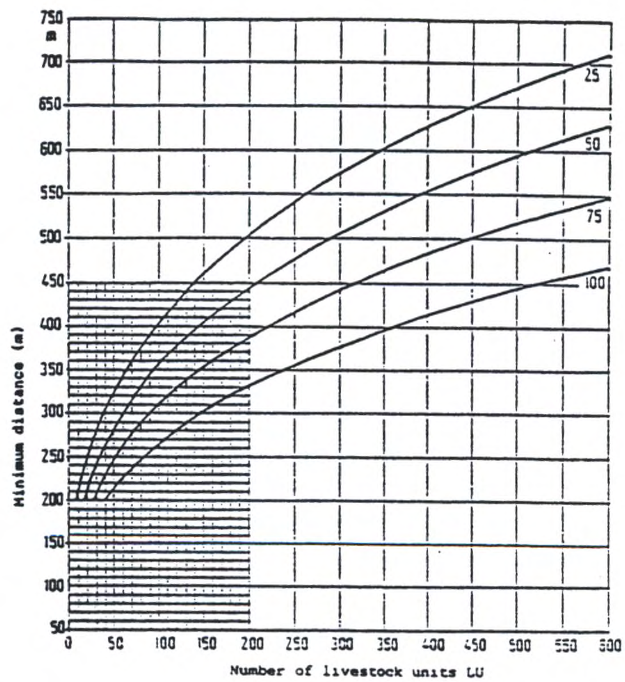


Figure 2. Distance diagram with point rating curves for hens. 1 LU - 500 kg liveweight.

Construction

In some countries, building regulations will specify the standard to which new accommodation must be built. In Denmark, all livestock buildings must have impermeable floors.

Ammonia Emissions from Buildings (Netherlands)

There is particular concern over ammonia emissions in the Netherlands (Netherlands Ministry of Agric., 1993) with an objective of reducing total emissions from Agriculture by 80% in 2010 compared to 1980. Legislation setting maximum ammonia emissions for poultry and pig housing will be introduced in 1997/8. The introduction of low emission livestock housing systems is currently being promoted via the "green label" scheme. A "green label" is awarded to systems which reduce emissions to 0.035 kg NH_3/layer/year and 0.015 kg NH_3/broiler/year. Farmers installing such systems are protected from the need for further changes for 15 years.

Poultry housing systems currently approved under this green label scheme include rapid in-house air drying systems for manure on belts in battery cages, battery houses with frequent manure removal to an enclosed storage area and suspended floor in-house air drying systems for broiler manure based on litter.

REGULATIONS GOVERNING STORAGE OF MANURES

No European Union Directives exist. Individual countries have controls which are aimed either at reducing water pollution, or increasing flexibility of land spreading, or at reducing emissions. Few controls exist in Greece, Portugal and Spain. In some countries (e.g. UK) controls are specifically aimed at liquid slurries, rather than solid manures, thus stored solid poultry manures may be exempt from some aspects of regulations. In France, controls apply to cattle and pig manure storage only.

In most cases compliance with regulations is required for new stores only, with a period allowed for old stores to be brought up to new standards.

Siting of Stores

In addition to constraints which may be applied, for a distance from dwelling houses to avoid odor nuisance, minimum distances from boreholes or water courses are also often specified. In the UK a minimum distance of 10 m from any drain, ditch or water course is required (D of #, 1991). Similar requirements apply in France, Ireland and Italy.

Ground water protection zones have been designated in many countries, being number I, II and II to denote vulnerability. In Belgium, Denmark and Germany installation of waste storage facilities is either prohibited or requires approval in such zones. France and Netherlands are preparing to enact such controls in the near future (Owen, 1993).

Sizing of Stores

Many countries specify minimum sizes for slurry and manure stores. In the UK the minimum storage period for new slurry stores is 4 months, although exceptions can apply. Minimum storage periods for solid manures vary from 4 months in France (6 months in Brittany) 6 months in Belgium (Flanders) and Germany and 9 months in Denmark. Standard figures for waste output volume may be used to determine minimum store size required. Standard figures may vary from country to country.

Construction of Stores

Those countries having regulations generally require stores to be designed and built to approved designs or to certain structural standards (D of E, 1991). In Denmark and the Netherlands solid manure must not be stored in fields prior to spreading and must be contained in a purpose built structure with an impermeable base.

Covering of Stores

Concern over ammonia emissions has led to the requirement to provide permanent or floating covers on certain liquid manure stores in the Netherlands, Belgium and Denmark. In the Netherlands all liquid manure stores built since 1987 have to be covered.

REGULATIONS GOVERNING LAND APPLICATION OF MANURES

The 1991 EC Framework Waste Directive requires number states to enact legislation which ensures that waste is "recovered or disposed of ... without risk to water, air, soil ... and without causing nuisance". Under this directive, those involved in the commercial disposal or recovery of waste must obtain a permit from the competent authority, or in some cases, may only need to register with that authority. In the UK, the government would want to ensure that spreading slurry or manure on agricultural land would not equate to waste disposal under this directive.

EC Nitrate Directive

Concern over nitrate in drinking water resulted in the EC Nitrate Directive (92/676). This requires member states to:

- Designate as vulnerable zones all known areas of land draining into water where the nitrate concentrations exceed, or are expected to exceed 50 mg/l.

- Establish action programs which will become compulsory within these zones at a date agreed between 1995 and 1999.

Proposed obligations to be met by all farmers in the zones include constraints on inorganic fertilizer use, and a requirement not to (in the initial period) exceed 210 kg/ha of total N in organic manures, averaged over the farm area each year. On sandy or shallow soils poultry manure application will not be allowed on grass between September 1 and November 1, and to fields not in grass between August 1 and November 1. Manure should not be applied to waterlogged frozen or snow covered ground, on steep fields or within 10 m of surface water. Farmers must keep records of fertilizer use and manure application.

In some cases (e.g. Netherlands) the whole country has been designated as a vulnerable zone. In others (e.g. England and Wales) specific and limited areas where problems exist have been provisionally designated for public consultation (MAFF, 1994).

The measures may have serious consequences for some poultry farmers who will have to export manures to other areas in order to comply with the upper limit on total N application. This limit equates to the stocking densities shown in Table 1.

Table 1. Calculated Limits: Poultry Manure at 210 kg/ha Total N per Annum

	Land area needed	Equivalent stocking rate
1000 Laying hens	3.00 ha	333 ha
1000 Broilers	2.90 ha	344 ha

(1 ha = 2.47 acres)

Phosphate (Netherlands)

In the Netherlands an alternative approach to control nutrient surplus has already been adopted, based on phosphate as well as nitrogen. From 1987 to 1990, a ceiling was being set on phosphate production by holdings. From 1991 onwards the aim has been to reduce the burden on the environment by tightening the standards. By 1995, the aim is for a maximum quantity of 150 kg/ha to be applied to grassland and 110 kg/ha to arable or maize. In 1996 this will reduce to 135 kg/ha and 90 kg/ha, respectively. These standards will be replaced by a minerals accounting system in 1997, designed to further reduce losses.

Table 2 shows land area which will be needed for poultry to meet the proposed maximum phosphate application limits proposed for arable land and maize.

Table 2. Calculated minimum areas needed to meet proposed phosphate limits for application to arable land (Netherlands)

	Land area needed	
	1995 110 kg/ha phosphate	1996 90 kg/ha phosphate
1000 Laying hens	4.55 ha	5.55 ha
1000 Broilers	2.18 ha	2.67 ha

Facilities ("manure banks") have been set up to redistribute manure or reprocess manure to overcome local surplus problems. There is also a national surplus problem, which may be overcome by exporting manure in future.

Other Controls on Manure Application Rates

In addition to the proposed controls described above, some other countries have existing controls, mainly designed to limit nitrate leaching. In Denmark, quantities of manure applied are defined in terms of livestock units per ha per year. 2.0 lu/ha/yr are set for poultry where one lu = 500 kg bodyweight. In some German states (Lower Saxony, Westphalia) there are limits on the number of "manure units: applied per hectare, equivalent to 240 or 360 kg/ha total N per annum.

In England and Wales there is currently no direct statutory control on application rates for manures, but a voluntary limit of 250 kg total N/ha/year is recommended in the Code of Good Agricultural Practices for protection of Water (MAFF, 1991).

"Closed Seasons" for Manure Spreading

In order to limit nitrate leaching and pollution some countries already have periods during which application of manure is prohibited. These normally relate to the late autumn/early winter period. In the Netherlands, application of manure is not allowed from September 1 to February 1. In Denmark solid manure may be applied between harvest and October 1 only to areas which are growing crops for the following winter.

Methods of Application

In order to limit ammonia loses, some individual countries have controls on method of manure application to land. In Denmark manure must be ploughed in immediately after application unless it is applied to growing crops.

In the Netherlands all manure applied to arable land must be ploughed in immediately following application. On grassland, all liquid manures must be subsurface injected, or applied to the surface of the ground within the grass sward, by an approved method shown to reduce ammonia emission by at least 50% (as compared with surface spreading).

CONCLUSIONS

Environmental regulations control many aspects of poultry production in most northern European countries. Such controls are likely to increase in future with some degree of uniformity being achieved amongst member states of the European Union. Variations will however, remain between and within individual countries. The Netherlands currently have the most comprehensive policy and strictest controls, as the country where environmental problems caused by intensive livestock farming are, in relative terms, the greatest.

REFERENCES

Baldock, A., and G. Bennett, 1991. Agriculture and the polluter pays principle. A Study of Six EC Countries. Institute for European Environmental Policy, London, UK. 231 pp.

Department of Environment, 1991. Control of pollution (silage, slurry and agricultural fuel oil) regulations (1001). D of E, London, UK.

EC, 1985. Council Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment. Official Journal of the European Communities, Brussels.

EC, 1991. Council Directive 92/676/EEC on nitrate in drinking water. Official Journal of the European Communities, Brussels.

Ministry of Agriculture, Fisheries and Food, 1991. Code of Good Agricultural Practice for protection of Water. MAFF, London. 79 pp.

Ministry of Agriculture, Fisheries and Food, 1992. Code of Good Agricultural Practice for protection of Air. MAFF, London. 74 pp.

Ministry of Agriculture, Fisheries and Food, 1993. Code of Good Agricultural Practice for protection of Soil. MAFF, London. 55 pp.

Ministry of Agriculture, Fisheries and Food, 1994. Consultation Document - Designation of Vulnerable Zones in England and Wales under the EC Nitrate Directive (91/676). MAFF, London.

Paduch, M., 1987. Present state of VDI - guidelines on odor assessment. In: Volatile Emissions from Livestock Farming and Sewage Operations. Elsevier Applied Science, London. pp. 38-53.

Netherlands Ministry of Agriculture, Nature Management and Fisheries, 1993. Environmental policies in agriculture in the Netherlands - nutrients and pesticides. The Hague. 20 pp.

Owen, J., 1993. Review of farm waste storage regulations in EC countries. Report to MAFF (unpublished). 39 pp.

NITROGEN UTILIZATION FROM POULTRY MANURES IN ARABLE CROPPING SITUATIONS

B. J. Chambers, R. B. Cross and R. J. Nicholson
ADAS Arable Research Centre
Anstey Hall
Maris Lane
Trumpington
Cambridge, CB2 2LF, England

Poultry manures are valuable sources of nitrogen (N) for crops, with the estimated annual UK production of 4.6 million tonnes containing in the region of 113,000 tonnes of N (Smith, 1991). A high proportion of this production is from large units located in predominantly arable areas in central and eastern England. Common practice is to apply the manure to arable stubbles in the autumn/winter period, with little apparent allowance being made by farmers in their inorganic fertilizer policies for the manure N value.

Previous UK experiments evaluating the N value of poultry manures have recorded N efficiencies of 60-70% (Davies and Farrar, 1982), 50% (Tinsley and Nowakowski, 1959) and between 15-75% for kiln dried poultry manure (Garner, 1970). In the USA, the Alabama Cooperative Extension Service estimated that 55% of the total N content of broiler litter will be available for crop uptake in the first year following application, and that over 3 years 70% of the N will be available (Payne and Donald, 1990).

The experiments reported here were designed to evaluate the effect of poultry manure application timing, nitrogen content and form, on the efficiency of N utilization by cereals.

EXPERIMENTAL DETAILS

Eleven field experiments were established in central and eastern England on a range of soil types between harvest years 1990 to 1992 (Table 1). Three poultry manure timing strategies were compared, viz: 1) autumn-early winter (September to December) on arable stubbles, 2) late winter-early spring (January to mid March) as a topdressing, and 3) spring (mid March to early May) as a topdressing.

Table 1. Site Location, Cropping and Soil Type Characteristics

Site name/location	Season	Cereal crop	Soil texture group	Effective over winter rainfall* mm
Cambridgeshire	1989-90	Winter wheat	Clay	212
	1990-91	Winter wheat	Clay	110
	1991-92	Winter wheat	Clay	151
Suffolk A	1989-90	Winter barley	Light loam over chalk	250
Suffolk B	1990-91	Winter barley	Medium loam over chalk	165
	1991-92	Winter wheat	Medium loam over chalk	166
Nottinghamshire	1989-90	Spring wheat	Light loam	222
	1990-91	Winter barley	Light loam	302
	1991-92	Spring barley	Light loam	59
Herefordshire	1990-91	Winter barley	Medium loam	307
	1991-92	Winter wheat	Medium loam	148

*Effective rainfall (i.e., rainfall- actual evapor-transpiration) following the autumn-winter manure application to end of drainage.

At all sites, except Nottinghamshire 1990 and 1991, the poultry manure was stored overwinter under a plastic sheet to ensure that the manure used for the spring topdressings was comparable to the autumn-early winter timing. To minimize the potential for ammonia volatilization losses following the autumn-early winter dressings, the manures were incorporated into the soil within 24-72 hours of application. At each application date, poultry manure was applied by hand at target rates of 120 and 240 kg/ha total N (actual rates ranged between 91 and 316 kg/haN).

Fertilizer N applications in the rage of 0 to 240 kg/ha N were applied in spring of each year (40 kg/ha N in late February/early March, with the remainder applied in April in relation to crop growth stage) to provide a fertilizer nitrogen response curve for each site. At six sites, the effect of including a nitrification inhibitor (DCD, dicyandiamide) with the autumn-early winter poultry manure dressing was evaluated. D.C.D. was intimately mixed with the manure at a rate equivalent to 20 litres/ha.

Each treatment was replicated three times in a randomized block design. Plot sizes were 3.75 m x 18 or 24 m. All sites had a satisfactory soil pH and nutrient status, and where necessary maintenance phosphate and potash fertilizer applications were made to the experimental area to ensure that neither nutrient was limiting. Grain yield assessments were made using plot combine harvesters.

Nitrogen efficiency of the applied poultry manures was calculated by comparison with "fitted" fertilizer N-grain yield response curves. Mean N efficiencies for the two application rates at each timing are presented in Table 3. Where DCD was included with the poultry manure, calculated N efficiencies take into account the 13 kg/ha N supplied in the nitrification inhibitor.

Table 2. Poultry Manure Type and Mean Analysis at the Three Application Timings

				Nitrogen (kg/tonne) freshwater)		
Site name/ harvest year	Poultry manure type	Dry matter (%)	Carbon: nitrogen ratio	Total	Ammonium	Uric acid
Cambridgeshire:						
1990	Broiler	70.2	ND	35.3	6.4	ND
1991	Broiler	78.7	6.2	40.6	6.5	5.9
1992	Broiler	70.2	6.0	41.8	7.2	5.6
Suffolk A:						
1990	Broiler	72.5	ND	36.1	6.2	ND
Suffolk B:						
1991	Broiler	73.8	6.6	40.5	6.9	7.0
1992	Broiler	66.8	5.9	39.9	8.4	5.1
Nottinghamshire:						
1990	Layer	57.0	12.1	24.6	4.8	ND
1991	Layer	57.0	9.5	21.4	4.8	2.8
1992	Broiler	60.9	7.4	19.1	2.6	0.7
Herefordshire:						
1991	Broiler	56.1	6.6	31.4	6.8	3.9
1992	Broiler	56.7	5.4	39.5	8.2	5.5
			Mean	33.7	6.3	4.7

ND = No data.

At each application date the poultry manure was analyzed to determine total N, ammonium N (i.e., inorganic N), uric-acid N (i.e., readily mineralizable organic N) and dry matter content, using standard ADAS methods (MAFF, 1986). Total N (TN), ammonium and uric acid N (AUN) analyses are reported in Table 2 on a fresh weight basis.

Effective rainfall (i.e., rainfall - actual evapor-transpiration) following the autumn-early winter manure applications up to the end of drainage was calculated for each site.

Evenness of Field Scale Application

Uneven or inaccurate spreading often gives rise to inefficient utilization of manure N. In a separate series of experiments, the evenness of application achieved with a moving bed spreader equipped with rear beaters, plus horizontal rotating discs, was tested. Transverse spread patterns for applied manures were assessed by collecting spread material in 0.25 m wide x 1.0 m long trays, laid out side by side across the spread width. Coefficient of variation (CV%) at various bout widths was calculated using a computer program. After determining optimum bout width to minimize CV%, the manure application rate was measured. The weight of the machine plus manure was determined, using portable weighing equipment, before and after spreading a length of 300 m.

RESULTS

Nitrogen efficiency of the late winter-early spring topdressings was on average 33% (range 21-51%) and for the spring topdressings 35% (range 21-46%). No differences ($P>0.05$) in N efficiency were found between the two topdressed timings at ten of the eleven sites.

The ammonium and uric acid N (AUN) content of the poultry manures was typically 33% of the total N content (19% ammonium N; 14% uric acid N). Comparing the amount of AUN supplied by the late winter to spring topdressings (8 sites, harvest years 1991 to 1992) and the amount of spring applied fertilizer N required to produce an equivalent grain yield, showed that the two were highly correlated ($P<0.001$) and not significantly different ($P>0.05$), Figure 1.

Table 3. Nitrogen Efficiency of Poultry Manure N in Relation to Application Timing

Site name/ harvest year	Nitrogen efficiency (%) Autumn /early winter	Late winter-spring	Spring	Autumn-early winter + DCD**	Significance of timing differences*
Cambridgeshire:					
1990	36	23	30	--	0.001 (SED = 1.9)
1992	42	41	41	--	NS
1992	46	38	33	--	0.05 (SED = 4.7)
Suffolk A:				35 (0.05)	
1990	23	26	33		0.05 (SED = 3.0)
Suffolk B:					
1991	38	34	46	38	NS
1992	38	43	41	40	NS
Nottinghamshire:					
1990	20	39	41	38	NS
1991	21	28	36	20	NS
1992	31	21	21	--	NS
Herefordshire:				38 (0.05)	
1991	22	51	36	--	0.05 (SED 9.7)
1992	26	22	27		NS
Mean		33	35		

*Significance of nitrogen efficiency differences between the three timings; NS P>0.05, P<0.05 (5%), P<0.01 (1%), P<0.001 (0.1%). Standard error of difference (SED) in brackets.

**Treatments where nitrification inhibitor (DCD) included with autumn-early winter poultry manure application. Significant treatment effects indicated in brackets.

Nitrogen efficiency of the autumn-early winter timings varied between 20 and 46%. On the light and medium loam soils, N efficiency of the autumn-early winter applications was markedly lower than the spring topdressings at 4 sites where effective rainfall was >200 mm. Similar N efficiencies (P>0.05) were recorded at the other 4 sites where effective rainfall was <200 mm. In contrast, on the clay soil sites in Cambridgeshire over the relatively dry winters in which the experiments were conducted, the autumn applications in 1989/90 and 1991/92 were more efficient (P<0.05) than the spring topdressings.

Inclusion of a nitrification inhibitor with the autumn-early winter poultry manure applications increased N efficiency at 3 sites where effective rainfall was >200 mm. For the Nottinghamshire 1990/91 site where effective rainfall was

302 mm, inhibitor use did not improve efficiency. It is probable that following application in September the inhibitor had been decomposed as a result of the warm soil conditions.

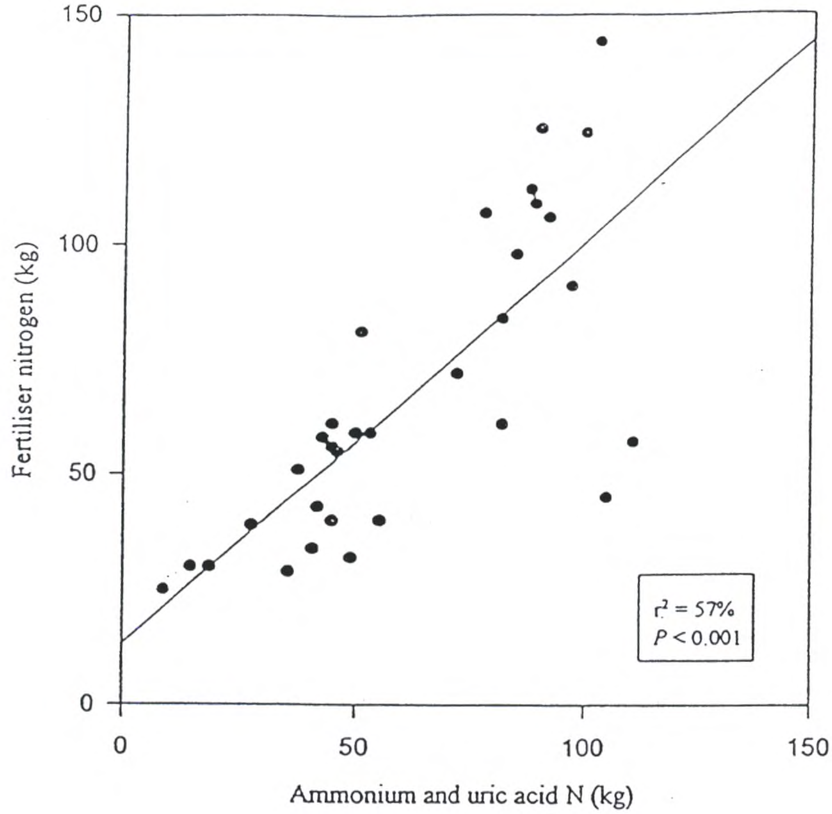


Figure 1. Ammonium and uric-acid N supplied by poultry manures and fertilizer N required to produce equivalent yields.

Spreader Test Results

The moving bed spreader tested applied dry broiler litter at a rate of 5.25 t/ha (179 Kg/ha N) in 1992, and a 'moist' litter at a rate of 8.8 t/ha (136 Kg/ha N) in 1993. Optimum bout width was 6 m. A CV% of 22 and 23% was recorded in each year, respectively. Results of the 1992 tests are shown in Figure 2. N efficiency in these field scale trials was 42% in 1992 and 23% in 1993, similar to the range of the small plot experiment.

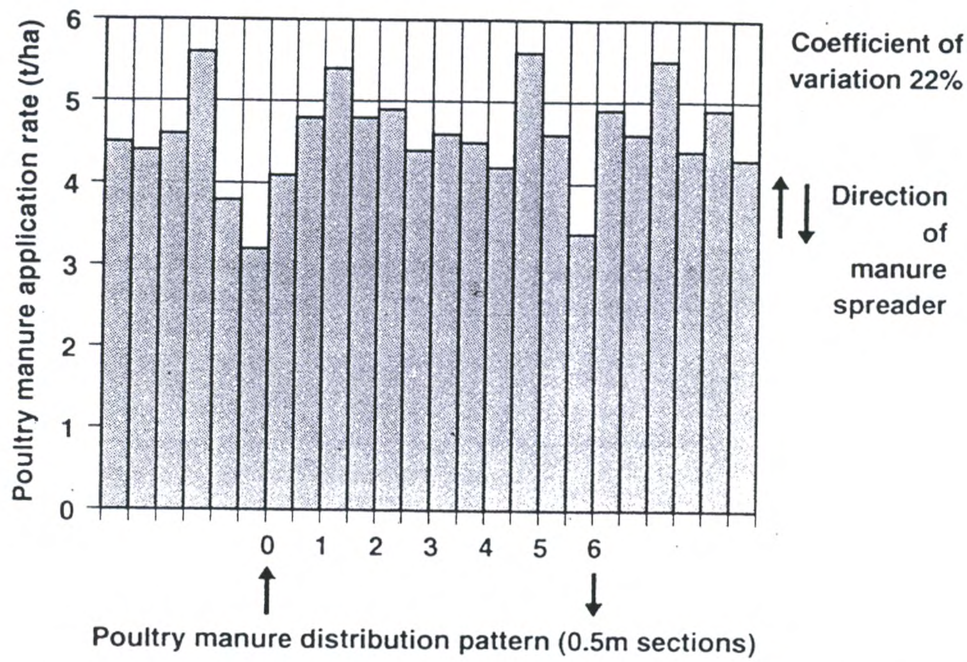


Figure 2. Application pattern achieved in field with poultry manure at lapped bout width of 6 m.

DISCUSSION

Nitrogen efficiency of the late winter to spring cereal topdressings was on average 34%, which is consistently lower than N efficiencies reported by previous UK workers (Davies and Farrar, 1982; Tinsley and Nowakowski, 1959) and in the USA (Payne and Donald, 1990). In these experiments, ammonia volatilization losses following surface application to growing cereal crops is likely to have been significant, compared to the previous UK experiments where the manures were incorporated into the soils following application. Pain and Jarvis (1990) reported ammonia N losses equivalent to 30% of the applied ammonium N (7% of total N) over a 5 day period following a surface poultry manure application. The USA Extension Services recommended that a allowance should be make for 20% ammonia volatilization losses where poultry manures are not incorporated (Payne and Donald, 1990).

The strong relationship between the AUN content of poultry manures and fertilizer N equivalent value (where there are no leaching losses), provides a basis for predicting the N value of poultry manures at a field level. The ready availability of uric-acid N to plants is supported by the work of Kirchmann (1991), who showed that uric acid N was completely decomposed within 10 days following soil incorporation. Payne and Donald (1990) recommend that the ammonium N content of poultry manure can be regarded as equivalent to fertilizer N where there are no volatilization losses. Beauchamp (1986) showed that 75-80% of the ammonium N content of poultry slurries was equivalent to fertilizer N.

Nitrification inhibitor inclusion with the autumn-early winter poultry manure applications improved N efficiency at 3 out or 4 sites where effective rainfall was >200 mm. A number of studies evaluated the ability of nitrification inhibitors to improve the efficiency of autumn/winter organic manure applications and to decrease nitrate leaching losses, have given inconsistent results (Pain et al., 1987). Kjellerup (1986) showed that the performance of inhibitors was strongly dependent on the soil temperature, with decomposition of the inhibitor taking place quickly in warm conditions, and Lande Cremer (1986) that the benefits of inhibitor use were influenced by cropping and soil type.

RECOMMENDATION - POULTRY MANURES

- On light and medium loam soils, where effective rainfall following application is in excess of 200 mm, there are likely to be significant improvements in N utilization from spring compared to autumn applications, as a result of decreased nitrate leaching losses.

- On clay soils in low rainfall areas of the UK, it is unlikely that a change in poultry manure timing strategy from autumn to spring will result in substantially improved crop N utilization.

- Poultry manure topdressings applied to cereals in spring have a mean N efficiency of 34%.

- The ammonium and uric acid N content can be regarded as equivalent to inorganic fertilizer N.

- Use of a nitrification inhibitor is only likely to improve N efficiency on light or medium soils where effective rainfall following application is greater than 200 mm.

- Equipment is available commercially which can spread manure evenly, at low rates.

ACKNOWLEDGEMENTS

We thank the UK Ministry of Agriculture, Fisheries and Food, for funding the work described in this paper.

REFERENCES

Beauchamp, E. G., 1986. Availability of nitrogen from three manures to corn in the field. Can. J. Soil Sci. 66, 713-720.

Davies, H. T., and K. Farrar, 1982. Experiments to determine the direct and residual effects of dried poultry manure on soil and crops. ADAS Soil Scientists Closed Conference Paper SS/C/744. MAFF Publications, London.

Garner, H. V., 1970. Experiments with kiln-dried poultry manure on agricultural crops and vegetables at Rothamsted, Woburn and other centres in 1933-39. Expl. Husb. 19, 13-28.

Jarvis, S. C., and B. F. Pain, 1990. Ammonia volatilization losses from agricultural land. Fertilizer Society Proceedings 298. Fertilizer Society, London.

Kjellerup, V., 1986. Nitrogen effect of slurring mixed with nitrification inhibitors, field experiments. In: Efficient Land Use of Sludge and Manuel (Eds. A. Dam Kofoed, J. H. Williams, and P. L-Hermite). Elsevier Applied Science, London, pp. 2-6.

Kirchmann, H., 1991. Carbon and nitrogen mineralization of fresh, aerobic and anaerobic animal manures during incubation with soil. Swedish J. Agric. Res. 21, 165-173.

Lande Cremer, L.C.N. dela, 1986. Preliminary results with the nitrification inhibitor dicyandiamide (DCD) in the Netherlands. In: Efficient Land Use of Sludge and Manure (Eds. A. Dam Kofoed, J. H. Williams and P. L'Hermite). Elsevier Applied Science, London, pp. 7-13.

MAFF, 1986. The analysis of agricultural materials. Ministry of Agriculture, Fisheries and Food. Reference Book 427, third edition. HMSO, London.

Pain, B. F., R. B. Thompson, Lande Cremer, L.C.N. dela and L. Ten Holte, 1987. The use of additives in livestock slurries to improve their flow properties, conserve nitrogen and reduce odours. In: Animal Manure on Grassland and Fodder Crops. (eds H.G. v.d. Meer et al.). Martinus Nijhoff, Dordrecht, pp. 229-246.

Payne, V. W. E., J. O. Donald, 1990. Poultry waste management and environmental protection manual. Alabama Co-operative Extension Service, Auburn University, Alabama 36849-5612. Circular ANR-580.

Smith, K. A., 1991. Waste production from Uk livestock. Internal report to the UK Ministry of Agriculture Fisheries and Food.

Tinsley, J., and T. Z. Nowakowski, 1959. The composition and manurial value of poultry excreta, straw droppings, composts and deep litter, IV. Results of manurial trials and general conclusions. J. Sci. Food Agric. 10, 232-241.

NUTRIENT MANAGEMENT PLAN IMPLEMENTATION: COASTAL ZONE ACT REAUTHORIZATION AMENDMENTS (CZARA) EFFECT ON AGRICULTURE

Mitch D. Woodward
National Program Leader
Soil Science
USDA, Extension Service
Room 3340 So. Building
Washington, DC 20250

Considerable material concern continues to be expressed over the impacts of non-point sources of contaminants on the quality of the Nation's surface and ground water resources. The four primary sources of agriculture contaminants are fertilizers, pesticides, animal waste, and sediment. They become contaminants as a result of management decisions to use practices and production systems that allow leaching below the root zone or transportation beyond the edge of the field to surface water.

Additionally, there is a growing concern that programs implemented by EPA through section 319 of the Clean Water Act have not been successful due, in part, to the absence of an effective process to develop state 319 plans. It has become clear that state lead environmental agencies, as well as EPA, have no program delivery capability beyond that of formulating regulations.

The passage of the CZARA in 1990 are legislation responses intended to address some of the concerns about the lack of effectiveness or current state 319 programs. A major focus will be on agricultural activities that generate nonpoint source contaminants. State implementation of the CZARA Management Measures has the potential to require nutrient management, pesticide management, animal waste, and/or sediment plans for individual farms in the coastal zone of each state.

CURRENT STATUS

Within the next 18 months federal and state governments will begin to require the adoption of science/technology based agricultural production practices through the CZARA program to protest coastal waters. The educational, technical assistance, and financial assistance of USDA are recognized as critical to accomplishing water quality policy objectives. The question is, "can agriculture focus, target, and sustain intensive program efforts to meet needs in these selected watershed areas?" "Is more regulation necessary or even effective?" "Can voluntary programs and certifications be effective?"

FUTURE CHALLENGES

To date, significant progress has been achieved as a result of the educational, technical, and financial assistance programs conducted through USDA. More specifically, land grant institutions are the repository for current technology and will be the focal point for the development of new technologies. However, it is also obvious that agriculture must enhance its capacity to actively participate in the development of state CZARA and 319 plans, but also assimilate new technologies into ongoing programs, adopt them to site specific applications and deliver programs that result in producer adoption of cost effective, environmentally sound production practices.

NUTRIENT MANAGEMENT PLANS - PRACTICAL CONSIDERATIONS

Harold W. Roller
Extension Agent, Agriculture
Virginia Cooperative Extension
Rockingham County
30 E. Gay Street
Harrisonburg, VA 22801

The Shenandoah Valley is one of the most intensive Agriculture areas in the nation in terms of livestock and poultry production. Most of you are aware of this because of your knowledge of our poultry industry. The following facts and figures will suggest the reasons we have done so much in the area of Nutrient Management and Water Quality. Most of the Shenandoah Valley is a part of the Potomac River Watershed and the Chesapeake Bay drainage area.

Table 1. Current Agriculture Statistics, Shenandoah Valley, Virginia

	Rockingham County	Other Valley Counties
Ag Income (1)	$370,998,000	$237,486,000
Grade A Dairies (2)	274	125
Dairy Cows (2)	24,600	12,750
Broilers (3)	77,000,000	57,000,000
Turkeys (3)	13,000,000	4,000,000
Beef Cattle (1)	62,921,000	132,024,000

1. Source - 1992 Agricultural Census (Preliminary Estimates).
2. Virginia Department of Agriculture & Consumer Services.
3. Virginia Poultry Federation.

Nutrient Management

About 1985, an educational program dealing with Nutrient Management-Water Quality and the increased emphasis on the cleanup of the Chesapeake Bay brought about a greater awareness on proper management practices or BMP's to be inaugurated on our farms.

We set up corn growing demonstrations on two dairy farms. Plots on one of these farms were maintained for 3 years with both corn and rye harvested each year. Results are shown in Table 2.

Table 2. Summary of Nitrogen Application and Corn Yields from Field Plots, Rockingham County, Virginia

Plot No.	Year	N Applied/A	Yield, Bu/Acre
1	1986	64# (Manure)	72.9
	1987	52# (Manure)	55.7
	1988	0#	121.3
2	1986	153# (Manure)	83.0
	1987	104# (Manure)	65.2
	1988	98# (Manure)	142.6
3	1986	64# (Manure) + 80# (Commercial)	70.7
	1987	132# (Manure) + 73# (Commercial)	87.6
	1988	126# (Manure) + 79# (Commercial)	149.0
4	1986	109# (Manure) + 140# Commercial	59.0
	1987	110# (Manure) + 143# (Commercial)	81.8
	1988	174# (Manure) + 75# (Commercial)	141.5

Farmers who attended field days to observe these demonstrations could see that there is considerable residual N in Rockingham County soils evidenced by 121 bushels of corn produced in 1988 on Strip #1 after a crop of rye had been harvested with no manure or commercial N applied for that year. They could also see that plant available nutrients for animal waste will replace commercial fertilizer. Futhermore, they could see that over fertilization is not only economically undesirable but may also reduce yields as evidenced by Strip #3 consistently out producing Strip #4 which was fertilized at a higher level. Soil tests after the 3 years showed that P & K levels were maintained by use of animal waste.

In 1987 the local Soil and Water Conservation District obtained cost share approval for litter storage structures under the Chesapeake Bay Cleanup Program. To date, over 179 such structures have been built in Rockingham and Page counties under the Cost Share program. Additional structures have been built without the Cost Share Assistance. In addition, manure storage structures for 55 dairy and 10 beef units have been built since 1984 under Cost Share. Many dairy farms had built storage units before 1984. At the present probably 85% of our dairy farms have some storage capacity for dairy waste.

With the building of litter storage buildings, the movement of poultry litter for livestock feed or fertilizer was accelerated. One businessman started a litter brokering business utilizing the producers with storage buildings as sources of cured litter needed for cattle feeding. At the present, 4 brokers are operating on a regular basis and have marketed over 30,000 tons of litter each year in both 1992 and 93, most going outside the county. Some litter for feed has been shipped as far as 225 miles providing low cost feed for beef cattle.

Another measure of the effectiveness of our educational programs is in sales of commercial fertilizer. In Rockingham County fertilizer sales dropped 32.6% from 1983-84 to 1990. (Table 3)

Table 3. Commercial Fertilizer Sales, *Rockingham County

1983 - 84	20,375 tons
1989	15,839 tons
1990	13,719 tons - 32.6%

Source - Virginia Department of Agriculture and Consumer Services.
*Includes fertilizer ingredients as well as commercially mixed fertilizers of standard composition i e. 10-10-10 etc.

Poultry Ordinance

The next major step was the adoption in 1988 of a Poultry Ordinance by Rockingham County after some 2 years of study and negotiations. Prior to adopting the ordinance, the issuing of building permits for poultry buildings was largely regulated through special use permits. Public hearings for such permits had become a 3 ring circus. This Poultry ordinance established set back distances for location of poultry facilities from neighbor's houses, property lines, roads, residential and industrial zones, public water supplies, schools or other similar factors. It also required all poultry producers to have a Nutrient Management Plan and an approved litter storage site where litter could be stored when conditions were unsuitable to spread the litter for fertilizer. Litter was also required to be covered when on site. These provisions where required to be met by July 1, 1994 or had to be met before any new structures were built after the ordinance was adopted.

Table 4. Provisions of Rockingham County Poultry Ordinance

Setback distances -150' from public highways
150' from property lines
300' from neighbors houses in A1 zone
600' or 900' from neighbors house in A2 zone
750' house in AR1 zone
1000' Incorporated towns, residentially zoned areas, public wells, etc.

Distances from property lines and neighbors houses are reducible by consent of the adjoining property owner.

Minimum acreage - 15A First house
5A for each additional house

Since the adoption of the ordinance 191 new poultry houses have been built in Rockingham County. Industry representatives now say they are much better off operating under the ordinance with its specific guidelines than they were before the ordinance was adopted.

Table 5. Poultry House Permits Issued in Rockingham County, VA

Year	Permits	Poultry Houses	New Growers Num	New Growers % of Permits	Square Footage New	Square Footage Avg.
1977-94*	605	810	333	55%	16,076,437	19,847
AVG.	35	47	19	55%	923,933	19,847
PRE 7/88	456	609	261	57%	11,490,800	18,868
AVG.	40	53	23	57%	1,007,965	18,868
SINCE 7/88	140	191	69	49%	4,451,067	23,304
AVG.	24	32	12	49%	754,418	23,304

* Through May 24, 1994

Five other Virginia counties have adopted some type of poultry ordinance modeled from the Rockingham Ordinance since 1988. All but one require a Nutrient Management Plan, and that county requires a signed statement covering the disposition of litter.

The Rockingham ordinance requires accountability of all litter produced so that a producer without ability to utilize his production must have approved sources of disposition and a written contract with the recipient. Plans must be renewed every 5 years. We are now starting to revalidate plans written in 1988 and 89.

Impact on Nutrient Management Plan

As of May 17, 1994 we had written 607 Nutrient Management Plans for compliance with the County Ordinance and had written 19 for recertification. These plans covered 561 poultry producers and 946 total farming units of which 143 were Grade A Dairy Farms who either were poultry producers themselves or were receiving poultry litter. These plans cover approximately 90,000 acres of crops.

In addition to the plans being prepared for compliance with the County Ordinance which are crop specific in their recommendations instead of field specific, two other agencies are preparing Nutrient Management Plans for either the cost share program or a state tax credit program. This program is available to farmers who purchase improved manure spreaders, sprayers, planters and tillage equipment. Both of these programs require field specific plans and are prepared by either Nutrient Management Specialists with the Virginia Department of Conservation and Recreation or conservation specialists working for local Soil and Water Conservation Districts. There is close coordination of effort in developing the two types of plans among the 3 agencies, Extension, Virginia Department of Conservation and Recreation and the Conservation Districts.

After eliminating duplication where farmers may need plans for two purposes i.e. tax credit and County Ordinance Compliance, a grand total of 849 Nutrient Management Plans have been prepared for the Central Shenandoah Valley Area covering over 151,000 acres.

A by-product of this effort and as a result of more farmers being aware of the value of animal waste as a fertilizer, many non-poultry farmers in the area are using poultry litter as a main source of crop nutrients. Some of these farmers are signers of contracts to take litter direct from a poultry producer while others are regular customers of the brokers. We have found that poultry litter can be hauled up to 100 miles for fertilizer use and still be competitive with commercial fertilizers. The unavailability of equipment to spread litter at proper rates in these non-poultry areas is a deterrent to getting more litter used by farmers in outlying areas. In the last 4 years one equipment dealer in Rockingham County has sold 93 spreader beds especially designed to handle poultry litter.

SUMMARY

What have we accomplished to date?

1. Farmers understand the need and their responsibility to properly use animal waste and fertilizer and not over apply plantfood beyond the crops need.

2. The poultry industry realizes nutrient management and litter disposal is an integral part of poultry production.

3. Commercial fertilizer sales dropped 32.6% from 1983-84 to 1990.

4. Four businesses have been started to broker poultry litter and handled over 30,000 tons on both 1992 and 1993 for livestock feed and fertilizer, mostly out of the county.

5. In the past 4 years one equipment dealer has sold 93 spreader beds especially designed to handle poultry litter, indicating increased awareness and emphasis on careful application and utilization.

FEED FORMULATION WITH ENZYMES TO REDUCE NUTRIENT OUTPUT

Craig L. Wyatt, Ph.D.
Technical Service Manager - N.A.
Finnfeeds International, Ltd.
1101 Perimeter Drive, Suite 475
Schaumburg, IL 60173-5008

Manure output from farm animals has not been a major concern for livestock producers until recently. Within the past few years, consumers (public) have become increasingly concerned about animal production practices which may have a direct impact on the environment. Southern Poultry and Egg Association found recently in a survey that over 76% of consumers would limit their purchasing of agricultural products including poultry if they felt management practices of that specific industry were harmful to the environment. Intensive animal production systems are at times inefficient converters of feed into desired animal products.

The diet fed to a bird will have a direct effect on the composition of the manure. As feed ingredient prices fluctuate and demand for common feedstuffs (i.e. corn, soybean meal) increase, pressure is placed on companies and nutritionists to utilize alternative sources of energy and amino acids to formulate low-cost balanced poultry rations. However, bioavailability of certain nutrients in these feedstuffs is limited when fed to poultry. Thus, work has been conducted to isolate and produce exogenous enzymes that target specific substrates to improve nutrient digestibility and performance (the first concern), and reduce fecal output which will have environmental benefits.

Nutritionists must consider digestibility and feed efficiency parameters in formulating rations, and should also consider total nutrient intake and retention along with waste output (Swick and Ivey, 1992). A broiler is an extremely efficient animal in converting feed to body weight gain, but still approximately 25% of gross energy, 50% of nitrogen and 55% of phosphorus intake are excreted in the waste (Figure 1). Both nitrogen and phosphorus are critical elements having an impact on local water quality (surface and ground). Reducing the amount excreted into the feces would have a beneficial effect on our environment. Most of the inefficiency in absorption of carbohydrates, nitrogen and phosphorus results from components in the feed which are indigestible by the bird (i.e. certain complex carbohydrates and phytin phosphorus).

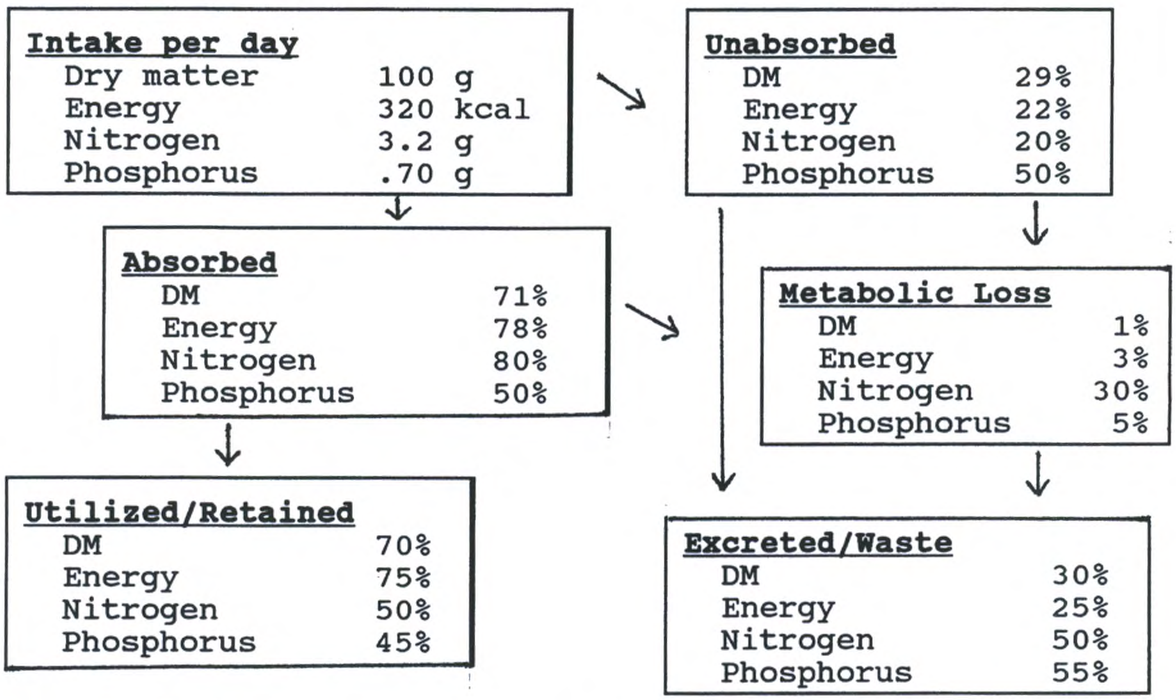


Figure 1. Nutrient intake, retention and excretion in a broiler.

Limited information is available on the extent of digestion of starch and non-starch polysaccharides (NSP) in poultry as compared to degradability of plant cell wall polysaccharides in the rumen. Many factors may be interfering in the animal's digestion process independent of age not allowing nutrients such as protein, fat and starch to be available to the bird's endogenous enzymes for further breakdown. Some digestible starch, protein and phosphorus escape degradation and absorption from the small intestine of monogastric animals because of the insufficiency or lack of specific endogenous enzymes (Graham et al., 1988; Pettersson and Aman, 1989). Consequently, potential benefits of developing and supplementing specific exogenous enzymes into diets for monogastric animals can be achieved by either complementing the animal's own digestive enzyme system or by introducing new enzymes normally not synthesized by the animal (Slominski, 1991).

Utilization of Exogenous Enzymes

As mentioned above, the NSP of cereal grains (i.e. barley and wheat) are thought to be responsible for the poor nutritive value of these feed ingredients. The inter-chain linkages of these molecules prevent aggregation resulting in compounds which are highly water soluble (Slominski, 1991). These NSP found in the cereal grains (especially barley) are highly viscous in solution and have been shown to cause impairment in nutrient movement and absorption from the lumen of the digestive tract of the bird (Classen et al., 1985). A study by Pettersson and Aman (1989) have shown pentosanase supplementation in wheat-rye diets improved ileal digestibility of both starch and protein, and apparent digestibility of organic matter, protein, fat and NSP in the whole intestinal tract of young broiler chicks (Table 1). It was postulated that enzyme supplementation is altering the digestive process through multiple pathways including a decrease in digesta viscosity and enzymatic disruption of intact cell walls releasing nutrients for absorption.

Table 1. Effect of pentosanase supplementation on performance (0-27 days), and ileal and fecal apparent digestibilities in broiler chicks fed a wheat-rye diet (Pettersson and Aman, 1989).

	Control	Enzyme Addition
Body weight (g @ 27d)	810[a]	951[b]
Feed conversion (g/g)	1.74[a]	1.61[b]
Ileal ap. digestibility (%)		
Organic matter	71.2[a]	75.2[b]
Crude protein	70.0[a]	76.2[b]
Starch	96.5[a]	98.5[a]
NSP	33.2[a]	36.0[a]
Fecal app. digestibility (%)		
Organic matter	72.4[a]	77.3[b]
Crude protein	76.0[a]	80.5[a]
Crude fat	58.5[a]	75.5[b]
NSP	40.0[a]	46.2[a]
App. metab. energy (kcal/g DM)	2.56[a]	2.77[b]

[1]Technical pentosanase mixture containing ß-glucanase and xylanase (Grinstead Products A/S, Denmark).
[a,b]Means with different superscripts are significantly different (P<.05).

Goodman and co-workers (1993) investigated the effects of total ß-glucan on intestinal viscosity in young broilers, and MEn values in both young and adult birds utilizing isogeneic barley lines. Feeding barleys with increasing levels of total ß-glucan decreased ME_n values in both ages of birds, but the response was non-linear. Although feeding an enzyme (Avizyme SX) reversed the effect of the ß-glucan by increasing both apparent and true MEn values, the greatest response was in chicks fed 50% barley test diets.

In young birds, AME_n were more negatively correlated to intestinal viscosity than to total ß-glucan levels. Enzyme supplementation increased body weight gain in the broilers, however, the percentage increase in gain was greater than the response observed in ME_n uplift. A possible reason for this response was the significant increase in dietary fat digestibility when feeding the enzyme preparation. Also, chicks fed the enzymes had a lower fecal output (approximately 15%).

Several studies have been conducted with Finnfeeds International to investigate the effects of feeding exogenous enzymes on digestibility of dietary nutrients in commercial broiler rations. A trial was conducted at Lakeside Research in Alberta, Canada to determine the effect of Avizyme SX on performance and ileal amino acid digestibility in broilers fed a barley-based (60%) diet through 42 days of age. At day 42, body weight and feed conversion were significantly improved and excreta output reduced by supplementing Avizyme SX (Table 2). Ileal amino acid digestibility was improved at 21 and 42 days of age, although for lysine, methionine, cysteine and threonine the response was greater at day 21 than day 42. Although there was no direct phytase added to the enzyme mixture, supplementing Avizyme SX tended to improve phosphorus digestibility which approached significance at 42 days.

Table 2. Effect of feeding an enzyme preparation1 on performance and ileal amino acid digestibility in broilers fed a barley-based diet.

		Barley control	Barley + AZ-sx	P-value
<u>0-42 days</u>				
Body weight (g)		2030	2150 (+ 6%)	0.05
Feed conversion (g/g)		2.06	1.88 (- 9%)	0.03
Excreta output (g/d)		227	185 (-19%)	0.01
<u>Ileal digestibility (%)</u>				
21 days	Lysine	70.7	79.9 (+13%)	0.01
	Methionine	66.8	78.0 (+17%)	0.01
	Cysteine	48.0	66.1 (+38%)	0.01
	Threonine	52.1	65.3 (+25%)	0.04
	Phosphorus	47.0	49.5 (+ 5%)	0.59
42 days	Lysine	76.1	80.8 (+ 6%)	0.02
	Methoinine	77.2	80.0 (+ 4%)	0.31
	Cysteine	61.5	67.4 (+10%)	0.35
	Threonine	58.1	64.5 (+11%)	0.05
	Phosphorus	42.4	50.0 (+18%)	0.11

[1]Enzyme preparation was Avizyme SX; Finnfeeds International, LTD (Finnfeeds Infoletter, SX.B.93.CAN.C.39)

A trial was also conducted at SAC (UK) to evaluate the effect of adding an enzyme preparation (Avizyme 1300; Finnfeeds Int.) to a wheat-based (63%) diet to determine performance, and ileal and fecal nutrient digestibility in broilers through day 21. Enzyme supplementation significantly increased ileal energy (8%), amino acid (~7%) digestibility and fecal amino acid digestibility (5%) compared to the control group at 21 days of age (Table 3). Improvements in apparent energy digestibility of 8% would, if attributed solely to the wheat component, equate to a 12% increase in available energy of this wheat. Whereas, the improvements in fecal amino acid digestibility's would equate to an increase in availability of ~29% for lysine, 14% for methionine+cysteine and 28% for threonine.

Table 3. Effect of feeding enzymes[1] on performance, and ileal and fecal nutrient digestibility in broilers fed a wheat diet through day 21.

	Wheat control	Wheat + Enzyme	P-value
Day 21			
Body weight (g)	493	485	>0.10
Feed conversion (g/g)	1.89	1.85	>0.10
Foregut viscosity (cps)	4.7	3.8	0.004
Illeal digestibility (%)			
Energy	67.4	73.1 (+ 8%)	0.02
Protein	72.1	77.3 (+ 7%)	0.007
Lysine	80.8	87.1 (+ 8%)	0.001
Methionine	76.8	84.3 (+10%)	0.03
Cysteine	48.2	65.6 (+36%)	0.05
Threonine	56.8	74.4 (+13%)	0.001
Fecal digestiblity (%)			
Energy	67.1	72.7 (+8%)	0.001
Lysine	81.7	85.9 (+5%)	0.007
Methionine	82.7	86.9 (+5%)	0.02
Cysteine	65.8	69.3 (+5%)	>0.10
Threonine	73.6	79.1 (+7%)	0.008

[1]Enzyme preparation was Avizyme 1300; Finnleeds International, LTC (Finnfeeds Infoletter, 1300.UK.94.03).

Responses to enzyme supplementation have also been observed in commercial laying hens. In two 8 week studies at Washington State University, the effects of supplementing exogenous enzymes in a barley-based ration on laying hen performance and energy digestibility was investigated (Wyatt, 1992). Corn and barley (50%) control diets were formulated to be isonitrogenous and isocaloric by supplementing blended fat (4.9%) in the barley diet. A third diet was fed consisting of an enzyme (Avizyme SX, Finnfeeds Int., LTD) added to the barley control diet.

There were no differences between the corn or barley control diets, but supplementing Avizyme SX in the barley diet improved egg production, egg mass and feed conversion compared to both control diets (Table 4). Although weight change was higher in the enzyme-fed hens, there was no difference in abdominal fat levels between the dietary treatments. These diets were also fed to young cockerels to determine ME_n values and fecal output. Birds fed either the corn or barley diet had similar apparent energy levels (2.98 kcal/g), but the ME_n value of the enzyme supplemented barley diet was 3.8% higher (3.093 kcal/g). The response in egg production and egg mass to enzymes would further suggest an increase in amino acid availability above the level of the control diets. Fecal output was decreased in Avizyme fed birds by 12 and 15% compared to the corn and barley fed groups, respectively.

Table 4. Effect of formulating diets using Wanabet barley and an enzyme mixture on several parameters for laying hens[1].

Parameter	Corn	Barley	Barley + Enz[2]
Final body wt (kg)	1.69	1.72	1.71
Body wt. change (g/8 wks)	15.9	0.00	25.3
Feed intake (g/hen/day)	110.2	111.6	112.7
Abdominal fat (% BWT)	4.39	4.55	4.47
Liver lipid (%)	7.51[a]	6.01[a]	5.46[b]
Egg wt (g)	62.8	63.8	63.2
Egg mass (g)	54.3[a]	54.8[a]	56.6[B]
Total egg prod. (%)	86.4[a]	85.9[a]	89.6[b]
Feed conv. (feed/egg mass)	2.04[a]	2.05[a]	2.01[b]

[1]Diets were formulated using an ME value of 2.94 kcal/g for barley.
[2]Enz= enzyme, Avizyme SXÖ, Finnfeeds International, LTD.

Similar results were observed in a Morocco trial in which laying hens were fed a barley-based diet (67% UK barley/20% soybean meal) supplemented with Avizyme SX. Young Brown layers were fed the diets from 23 to 52 wks of age, but only data from wks 23-26 will be shown (Table 5). Feeding Avizyme SX improved egg production and feed conversion by 3% and egg mass by 5%, even early in the laying cycle (it is thought that enzymes have a greater response as time increase) (Graham and Bedford, 1993). Supplementing the enzymes reduced excreta output significantly by 13% compared to the control group.

Table 5. Addition of Avizyme SX to a barley-based layer diet from 23 to 26 wks of age on performance and fecal output.

	Barley control	Barley + Avizyme SX	% Improvement
Egg production (%)	84.4	87.3	+3.5%
Feed intake (g/hen/day)	116.3	117.3	
Feed conversion (g/g)	2.39	2.32	+3.0%
Mean egg weight (g)	57.5	58.2	
Egg mass (g)	48.6	50.8	$4.5%
Fecal output (g/day)	186.7[a]	162.0[b]	-13.2%

[a,b] Means differ significantly from control (P<0.001).

Although the computer has allowed individuals to quickly formulate a least-cost balanced ration, many nutrients are at levels higher than the requirement because of the uncertainty in availability to the bird. Titration studies are being conducted to reduce the nutrient level in the diet to obtain optimal performance with limited excess. Diets are being formulated based on digestibility or availability values instead of total levels which continues to reduce the levels of certain nutrients closer to the animals requirement and limits excess in waste. Consequently, if an enzyme supplemented into the diet would increase availability of certain nutrients such as protein and amino acids, there would be a further reduction in nitrogen in the fecal output.

A recent study at AFRC (Roslin, Scotland) investigated the effects of uplifting (increasing) the AME and protein/amino acid specifications of wheat in the computer diet formulation and its impact on 21 day chick performance. Chicks were fed isocaloric and isonitrogenous (formulated) test diets in which the wheat AME was increased 6% and the crude protein/amino acid profile increased either 10 or 20%. Test diets were fed with (0.1%) or without an enzyme mixture (Avizyme 1300®; Finnfeeds Int.). Increasing the wheat formulation for protein/amino acid contents by 20% reduced bird performance relative to the wheat control indicating that they are not isocaloric and isonitrogenous. Supplementing Avizyme 1300 allowed the wheat formulation for AME to be increased by 6% and protein/amino acids by 20%

without affecting broiler performance through day 21 (Table 6). The enzyme significantly decreased foregut viscosity in all test diets.

In summary, many studies have shown the possible mechanisms of exogenous enzymes in altering the degradability of cereal grains which are poorly utilized by poultry. The utilization of enzyme preparations in commercial poultry diets are becoming more common practice, especially in diets containing such cereal grains as wheat, barley and rye. Addition of enzyme preparations to a diet appears to improve the apparent digestibility of many nutrients which may allow for optimal performance while reducing the amount of nutrients excreted into the manure. However, to further use these feed additives in an efficient manner in poultry diets, a nutritionist maybe able to uplift the nutrient value (i.e. energy and protein) of the target ingredient and account for nutrients that were not available to the animal prior to the use of enzymes.

Table 6. Effect of supplementing an enzyme mixture1 and increasing the wheat formulation values for AME and protein/amino acid content on broiler performance.

	Weight gain (g)	Feed:gain	Foregut viscosity (cps)
Wheat control	620[ab]	1.56[abc]	6.9[c]
Control + Enzyme	637[a]	1.54[4]	3.1[ab]
Wheat (+6% ME & +10% CP/AA)	601[bc]	1.63[bcd]	6.6[c]
W (+6% ME & +10% CP/AA + Enz.	607[bc]	1.61[bcd]	2.8[a]
Wheat (+6% ME & +20% CP/AA)	590[cd]	1.66[d]	4.8[bc]
W (+6% ME % +20% CP/AA) + Enz.	620[ab]	1.58[ab]	2.9[a]

[a-d]Means not sharing a superscript differ significantly (P<0.05).
[1]Enzyme preparation was Avizyme 1300; Finnfeeds International, LTD (Finnfeeds Infoletter, 1300.UK.94.06).

REFERENCES

Classen, H.L., G.L. Campbell, B.G. Rossnagel, R.S. Bhatty and R.D. Reichert, 1985. Studies on the use of hull-less barley in chick diets: Deleterious effects and methods of alleviation. Can. J. Anim. Sci. 65:725.

Goodman, T.N., C.L. Wyatt and B. Wood, 1993. Effects of feeding high ß-glucan barleys on metabolizable energy values in young and adult chickens. J. Anim. Sci. 71:181.

Graham, H., W. Lowgren, D. Pettersson and P. Aman, 1988. Effect of enzyme supplementation on digestion of a barley/pollards-based pig diet. Nutr. Rep. Inter. 38:1073.

Graham, H. and M. Bedford, 1993. A role for enzymes in reducing environmental pollution from manure. Finnfeeds Technical Report.

Pettersson, D. and P. Aman, 1989. Enzyme supplementation of a poultry diet containing rye and wheat. Br. J Nutr. 62:139.

Slominski, B.A., 1991. Carbohydrates in feedstuffs in relation to dietary enzyme use. Proceedings of the Western Nutrition Conference, pp. 140.

Swick, R. and F. Ivey, 1992. Phytase: The value of improving phosphorus retention. Feed Management 43(1):8.

Wyatt, C.L., 1992. Enzyme products to improve energy and protein utilization from poultry diets. Proceedings of Pacific Northwest Animal Nutrition Conference 27:111.

ESTIMATING MANURE PRODUCTION BASED ON NUTRITION AND PRODUCTION: LAYING HENS

Paul H. Patterson
Assistant Professor
Department of Poultry Science
The Pennsylvania State University
223 Henning Building,
University Park, PA 16802-3501

Nationwide poultry producers have been dealing with new regulations, or anticipating legislation that impacts how poultry manure is managed. An aggressive model to which United States law makers have looked to is the Netherlands' Policy on Manure and Ammonia (Anonymous, 1993). In three phases the Dutch are pursuing a target of nutrient equilibrium by the year 2000, e.g. balancing nitrogen and phosphorus applications with crop utilization.

In Pennsylvania new legislation enacted into law in May of 1993 seeks to abate non-point sources of pollution arising from livestock enterprises. The exact language of the Pennsylvania regulations are currently being drafted by the Department of Environmental Resources (DER) and a 15 member Nutrient Advisory Board. It calls for the training and certification of Nutrient Management Specialists that will write Nutrient Management Plans for livestock farms with greater than 2 animal equivalent units (AEU) per acre of arable land. One AEU is equal to 1000 lb live weight averaged annually. Nitrogen is the primary nutrient of concern from which regulations will be drafted, although, appropriate phosphorus management will most likely be written into a farms management plan. Some research will be conducted with the funds appropriated for nutrient management and will include quantifying the loss of gaseous nutrients from livestock enterprises and methods to control their release.

Accurate data on poultry manure production, and nutrient concentration are critical when writing a competent, and fair nutrient management plan that will sustain water quality, as well as the poultry industry. Many in Pennsylvania felt that existing table values published in the DER Poultry Manure Management manual (Graves, 1986) do not accurately reflect current body weights, feed consumption, manure production, concentration, or management conditions of commercial poultry today. Furthermore, literature values for Leghorn hens were most often determined with birds weighing 4 or more pounds with little information about the diets, management of the birds and manure, or how the manure samples were taken. With knowledge that DER planned to author new legislation for nutrient management, the Pennsylvania Poultry Federation (PPF) funded several studies with the Poultry Science Department at The Pennsylvania State University to determine the nutrient concentration and production of manures from modern commercial poultry including: Leghorn pullets and layers, broilers and turkeys. The preliminary results from this work with laying hens is the subject of today's presentation.

Objectives

1. To measure and quantify the manure nutrients produced by commercial Leghorn hens;
2. Provide meaningful nutrient values to the Pennsylvania Nutrient Management Board and DER;
3. Further dietary and management strategies to reduce nutrient deposition.

MATERIALS AND METHODS

Eight flocks (85,000-130,000 birds) from independent and contract producers were used for the study. Four flocks laid for a single cycle, and the other four were molted and carried through a second cycle of egg production. All hens were housed in high-rise facilities with nipple watering systems, and basement manure pits. Ventilation systems were side wall inlets at the soffit under negative pressure generated by exhaust fans located in the pits. Strains included the Dekalb Delta, and XL, Hyline W-77, Babcock B-300, and H&N.

Twice during the life of each flock manure core samples from 18 representative locations were pooled into 6 samples and analyzed for moisture, total-N, NH_3-N, P_2O_5, K_2O, Ca and Mg. Total-N was determined by micro-Kjeldahl digestion and a Technicon auto analyzer, NH_3-N was measured with a gas electrode and potentiometer. For Ca, P and Mg determinations samples were dry ashed and digested with HNO_3-HCl and measured by inductively coupled plasma (ICP) (Doty et al., 1982). Most often manure samples corresponded with the loading out of manure. At this time the number of loads would be counted and the average load weights would be determined.

Weekly flock production records including: egg production, egg weight, mortality, body weight, feed consumption and dietary crude protein, phosphorus, potassium, calcium and magnesium were collected with each flock. Pre-lay, layer, and molt diets ranged in dietary crude protein (CP) from 8.3-20.2%, total phosphorus from 0.41-0.94%, potassium from 0.38-0.93%, calcium from 1.49-5.85%, and magnesium from 0.04-0.37%. From these data total nutrients entering the hen house as feed, and leaving the house as manure, mortalities, body weight gain and eggs were calculated (Cunningham and Morrison, 1977ab; Naber, 1979; Palafox and Elodie Ho-A, 1980; Hester, 1986; Vandepopuliere et al. 1992).

RESULTS AND DISCUSSION

Nutrient concentration in the manure varied a great deal as can be seen in Table 1. Factors possibly affecting this variability include 1) the digestive health and physiology of the bird, 2) the composition and form of the diet, 3) the stage of growth and productivity, and 4) the management system of waste collection and storage (Fontenot et al., 1983). The greatest range in values were observed with NH_3-N varying more than 14 fold from the highest to lowest values. Manure moisture, P_2O_5, K_2O and Mg levels ranged no more than 4 fold, while total-N, and Ca ranged less than 5 fold. In general, manure total-N was higher in manure that had been stored for shorter periods of time and from hens on higher protein diets. Manure P_2O_5, and Ca concentrations tended to increase with storage time and age of the flock. The average Ca concentration (15.38%) reported in Table 1 is greater than the 5.5% reported by Fontenot et al. (1983) for caged layers, however, it was unclear whether their samples were collected daily or allowed to accumulated over time as is the case in a commercial setting. Similarly, P_2O_5 concentrations ranging from 1.8-4.5%, and K_2O from 1.7-2.8% reported in the literature (Fontenot et al., 1983; Graves, 1986; Mitchell et al., 1990; North and Bell, 1990) are less than those determined in this study.

Table 1. Manure Concentration (%) "Dry Matter Basis"

Value	Total-N	NH_3-N	P_2O_5	K_2O	Ca	Mg	Moisture
High	9.42	5.98	11.73	5.72	29.47	1.98	75.40
Low	1.98	0.41	3.71	2.16	6.02	0.56	32.10
Mean	4.85	2.49	7.12	4.03	15.38	1.12	60.01

n=77.

Based on the nutrient analysis of the manure and the quantity removed from six flocks summarized to date, nutrient production per 1000 lb live body weight was calculated (Table 2). Annual feed consumption averaged 22,218 lb per 1000 lb live weight, or 22.9 lb feed per 100 hens per day. Hen weight averaged 3.8 lb. Manure production expressed as lbs per 100 hens per day equalled about 7.5 lb, or 7,249 lb (3.62 tons) per 1000 lb live weight per year on an as is basis. Manure samples contained approximately 60% moisture. North and Bell (1990) reported 11.4 tons per 1000 lb live weight per year based on fresh manure (82% moisture) while Mitchel et al. (1990) reported 8.75-11 tons at 75% moisture. Even if expressed on a similar 60% moisture basis, the tonnage reported herein (3.62) is less and possibly attributed to the loss of carbon dioxide, ammonia, and other gases during the composting process of long term storage. Values in this study correspond with the more than 50% loss in manure volume often observed with long term storage (North and Bell, 1990). Estimated values for mineral nutrients and ammonia per 1000 lb of live weight, are also listed in Table 2.

Table 2. Manure Concentration (%) "Dry Matter Basis"

Value	Feed intake	Manure	Total -N	NH_3-N	P_2O_5	K_2O	Ca	Mg
High	23,720	9,571	248	212	273	151	652	48
Low	20,658	5,946	80	31	140	84	423	21
Mean	22,218	7,249	141	65	227	128	520	34

n=6.

Nutrients delivered in the feed were partitioned among the manure, eggs, mortalities, and live weight gain (Table 3). In the case of P, K, Ca, and Mg the majority of feed nutrients were lost to the manure. Nitrogen deposited in eggs as protein accounted for approximately 10% more N than was lost to the manure. Approximately 50% of feed Ca was estimated to remain with the egg shell, while only 12-16% of the feed P, K or Mg remained with the egg. On the average, pullets were housed at 2.9 lb and completed their cycles at 3.8 lb, so that 0.9 lb of carcass weight was added in the laying house. The quantity of nutrients utilized for carcass gain or lost from the flock as mortalities was very small. Feed N and P partitioned to the carcass approached only 1.0 and 0.5%, respectively. The sum of the estimated nutrients found in the manure, eggs and carcasses never equaled 100% of the nutrients delivered in the feed. Unfortunately, the errors associated with manure tonnage and analysis, flock records and literature values for carcass and egg nutrients do not allow for 100 percent accountability. While one would anticipate P, K, and Mg to be stable in the manure, N can be lost to the atmosphere. Based on the sum of N determined from manure, eggs, and carcass an additional 41.88% could have been lost to the atmosphere as ammonia nitrogen. For P and K the majority was found in the manure while approximately 10% could not be accounted for. Calcium partitioning appeared to be the most accurate with a similar percentage recovered in the egg and manure and the sum of all fractions only over estimated by 5%. Following N, Mg was the least accounted for nutrient (71.05%) with the majority partitioned to the manure (58.73%) and eggs (12.26%).

Table 3. Flock Partitioning of Feed Nutrients (%)

Nutrient	Feed	Manure	Eggs	Carcass	Sum
Nitrogen	100	23.65	33.56	0.91	58.12
Phosphorus	100	70.91	16.70	0.46	88.07
Potassium	100	78.24	12.33	0.20	90.77
Calcium	100	55.93	49.54	0.14	105.61
Magnesium	100	58.73	12.26	0.06	71.05

n=6.

When estimating the manure nutrients produced by modern Leghorn flocks certainly feed consumption and egg production influence nutrient utilization. Based on the premise that records for feed consumption and nutrient composition, as well as egg production and case weights are maintained by most producers, the relationship between their values and excreted nutrients can be calculated (Table 4). The correlation and regression coefficients and ratios of manure nutrients (N, P, K) and manure production are compared with feed nutrients, feed consumption, and egg production on a pound for pound basis.

The negative correlation between manure and feed N suggests that as more nitrogen in the form of protein is consumed by a flock one would recover proportionately less N in the manure. This was shown best with the two molted flocks whose manure remained in the hen house for more than 80 weeks losing N, while the hens continued to consume protein N over an extended period of time. When molted flocks are correlated with single cycle flocks with more concentrated manure N, the slope of the regression lines and correlation's are negative. On a pound for pound basis .2243 lb of manure N were produced per lb of feed N consumed. This would correspond to approximately 11.5 lb of manure N per ton of 16% CP layer mash consumed (320 lb CP per ton). Pound for pound manure P, K and total production were all positively correlated with the quantity of nutrients consumed in the feed, feed consumption and eggs produced (Table 4).

The most significant regression relationships were realized with Manure x Feed and Manure x Egg, each with a significant (P<.05) quadratic line. Based on the lb/lb ratio, for each lb of feed consumed, .3357 lb of manure would be generated, e.g. 671 lb of manure per ton of feed consumption. Significant regression relationships coupled with the high Manure x Egg correlation (.7408) suggest that manure production can best be estimated by calculating a flocks total egg mass. On a lb/lb basis, .7137 lb of manure are generated for each lb of eggs, or 1.07 lb manure per dozen large eggs.

Table 4. Flock Nutrient Relationships With Manure, Feed and Egg Mass

Parameter	Correlation	Regression probability linear	Regression probability quadratic	Ratio	Ratio
Manure N x Feed N	-.5932	.2145	.4778	.2243	449
Manure P x Feed P	.7145	.1107	.3417	.7112	1422
Manure K x Feed K	.6819	.1357	.3102	.7537	1507
Manure x Feed	.6130	.1956	.0469**	.3357	671
Manure x Egg	.7408	.0920*	.0393**	.7137	1427

n=6, *P<.10, ** P<.05.

CONCLUSIONS

1) Modern Leghorn hens are smaller, and produce less manure under commercial high-rise conditions than literature values would suggest.

2) Manure N concentrations are similar to reported values, while P_2O_5, K_2O, and Ca are more concentrated.

3) Approximately 42% of feed nitrogen is lost to the atmosphere as ammonia N.

4) Manure production is best estimated with the Manure x Egg mass relationship (correlation = 0.7408, linear regression P=.0920, quadratic regression P=.0393).

REFERENCES

Anonymous, 1993. The Netherlands' policy on manure and ammonia. Ministry of Agriculture Nature Management and Fisheries, Information and External Relations Department, The Hague, NL.

Cunningham, D. C., and W. D. Morrison, 1977a. Dietary energy and fat content as factors in the nutrition of developing egg strain pullets and young hens. 2. Effects on subsequent productive performance and body chemical composition of present day egg strain layers at termination of lay. Poultry Sci. 56:1405-1416.

Cunningham, D. C., and W. D. Morrison, 1977b. Dietary energy and fat content as factors in the nutrition of developing egg strain pullets and young hens. 3. Effects on hepatic lipogenic enzyme activity and body chemical composition during the first 20 weeks of lay. Poultry Sci. 56:1783-1791.

Doty, W. T., M. C. Amacher, and D. E. Baker, 1982. Manual of methods. Soil and Environmental Chemistry Laboratory, The Pennsylvania State University, Information Report 121.

Fontenot, J. P., L. W. Smith, and A. L. Sutton, 1983. Alternative utilization of animal wastes. J. An. Sci. 57(Suppl. 2):221-233.

Graves, R. E. ,1986. Poultry manure management. Pennsylvania Department of Environmental Resources, Harrisburg, PA.

Hester, P. Y., 1986. Shell mineral content of morning versus afternoon eggs. Poultry Sci. 65:1821-1823.

Mitchell, C. C. , Jr., J. O. Donald, and J. Martin, 1990. The value and use of poultry manure as fertilizer. Alabama Cooperative Extension Service Circular ANR-244.

Naber, E. C., 1979. The effect of nutrition on the composition of eggs. Poultry Sci. 58:518-528.

North, M. O., and D. D. Bell, 1990. Waste management. Pages 879-885 in: Commercial Chicken Production Manual. 4th ed., Van Nostrand Reinhold, New York, NY.

Palafox, A. L., and Elodie Ho-A, 1980. Effect of zinc toxicity in laying white leghorn pullets and hens. Poultry Sci. 59:2024-2028.

Vandepopuliere, J. M., J. J. Lyons, and C. D. Fulhage, 1992. Recycling cage layer mortalities by composting. Poultry Digest, Sept. pp. 24-30.

ESTIMATING NUTRIENT LEVELS IN BROILER LITTER

Larry Vest
Extension Poultry Scientist
University of Georgia
P.O. Box 95
Calhoun, GA 30703

The value of manure as a source of plant nutrients has been recognized for centuries. Poultry manure contains many essential nutrients required for crop production. In spite of its beneficial effects on plant growth, manure constitutes only a very small percentage of nutrients applied to cropland when compared to commercial fertilizer.

There are several reasons why poultry manure is not used to its fullest potential. Among these are lack of information on the value of manure as a source of plant nutrients b) failure to recognize how and where to utilize it; and c) lack of recognition of its economic value.

The objective of this project was to continue the 1989-90 study of those factors which affect the mineral content of broiler litter, and to evaluate the methods used in establishing broiler litter mineral content.

MATERIALS AND METHODS

Numerous samples of litter were taken from commercial broiler houses in northwest Georgia after removal of each flock at 40-44 days of age. The samples were taken from producers of two different integrators. Grower feed samples were taken and analyzed as well. The broiler houses were bedded with pine shavings or sawdust. The elemental composition of pine shavings is given in Table 1. Each house was normally cleaned completely once a year. After each flock was removed, the litter was worked with a cruster and allowed to set until a new flock was received (10-14 days later). Frequently a thin layer of sawdust or shaving were added a few days prior to the arrival of the new flock.

Table 1. Elemental Values for Pine Shavings

Elements		Level
N	%	.08
P	%	<.02
K	%	.04
Ca	%	.07
Mg	%	<.02
Na	ppm	38
Mn	ppm	110
Fe	ppm	113
Al	ppm	127
B	ppm	<1
Cu	ppm	3
Zn	ppm	10

Chemical Analysis

Total Kjeldahl nitrogen was determined by digestion of a one gm sample in a block digester at 420°F in 13 ml H_2S04, seven gm K_2S04 and .35 gm HgO (used as a catalyst). Digestion was accomplished in 50 minutes. The digest was cooled, diluted with 70 mls water and placed on a Tecator model 1030 auto with 70 mls water and placed on a Tecator model 1030 auto analyzer. Fifty mls of 40% NaOH and 3.75% $Na_2S_2O_3$ were added and the ammonia was steam distilled into one percent boric acid with mixed bromcresol green-methyl red indicator and titrated to the indicator end point with .25NHCl.

Determination of the mineral components was accomplished by a nitric and perchloric acid digestion of a one gm portion of the litter sample. The digest was subsequently diluted with deionized water and analyzed on a Thermo Jarrell Ash model 61 E inductively coupled plasma emission spectrograph.

Determining Available Nutrients

Three methods are generally used to establish the nutrient content of poultry waste. These include: a) Having waste samples analyzed, b) Summarizing nutrient content from tables, or c) Using data on feed composition and bird utilization.

Analysis of samples: Having waste samples analyzed in a qualified laboratory provides the most accurate information on nutrient value. However, the lab results are only as good as the quality of the composite sample collected in the field and the sample taken in the lab.

It is extremely important to obtain a representative field sample. Vandepopulier et al., (1992) reported that a representative litter sample could be obtained by taking a composite sample from a 10 inch wide strip across the broiler house midway in both the brooding and growing sections.

After getting a representative sample of litter to the laboratory the prospects for variations in the elemental values are not eliminated. It was pointed out by the laboratory director that preparing the sample for analysis with bulky particles like pine shavings made collecting a representative sub-sample difficult. Most field samples were analyzed twice. The average variation by element is shown in Table 2. The values for calcium and phosphorus were most variable, 10.8 and 9.8%, respectively (Table 2). Therefore, the procedure for collecting and handling the sample is very important.

Table 2. Average Variation in Values for Each Field Sample

Element	Avg. Variation Percent
N	4.0
P	9.5
K	7.0
Ca	10.8
Na	7.2
Mg	5.5
Fe	3.1
Al	4.0
Cu	5.0
Mn	5.7
Zn	7.0

Summarizing nutrient values from tables: If a waste sample cannot be analyzed, the person may use published data to arrive at an approximation of the nutrient content of the waste. However, this method has its shortcomings, because the nutrient content of waste can vary widely. Eno, 1962 reported on many of the factors which influence elemental levels in poultry manure. These factors include: number of birds per unit area, feed, kind and amount of litter, time in use and management factors. The degree with which elemental changes have occurred in the northwest Georgia area over the past four years are demonstrated in Table 3. The greatest decline of elements occurred with iron and aluminum. The principle sources of iron and aluminum are soil, water, phosphate sources and poultry by-product meal. The major fertilizer components (N, P & K) declined at the rate of approximately 20 percent (Table 3). Declines in the levels of elements in the rations of company A over the past few years with the exception of iron and aluminum tend to validate declines in the litter (Table 4).

Table 3. A Comparison of the Elemental Composition of Broiler Litter in Northwest Georgia (Dry Basis)

Element		1990	1994	Difference	%
N	%	4.37	3.37	-1.00	22.88
P	%	1.90	1.43	- .47	24.74
K	%	2.75	2.17	- .58	21.09
Ca	%	3.08	2.00	-1.08	35.06
Na	%	.67	.60	- .07	10.44
Mg	%	.63	.42	- .21	33.33
Fe	%	.28	.13	- .15	53.57
Al	%	.21	.10	- .11	52.38
Cu	ppm	558	354	-204	36.55
Mn	ppm	428	293	-135	31.54
Zn	ppm	353	282	- 71	20.11

Feed Elemental Levels and its Concentration in Litter

The major accumulation of elements in the bedding material over time is an expression of those contained in the feed and water which are not absorbed during digestion. Using the elemental level of a company grower ration and a concentration factor would serve as a method to estimate the level of elements in the litter. Also, the comparison of a particular element in the feed and litter could serve as a method to evaluate the bird's ability to utilize it.

The degree of concentration of N, P, K, Ca, Na and magnesium tend to follow a similar pattern for both companies A and B

(Tables 5 & 6). This similar pattern was observed by Vest and Dyer (1993).

Table 4. Average Elemental Content of Grower Rations Used by a Commercial Broiler Company in 1990 and 1994 (Dry Basis)

Element		1990	1994	Percent Difference
N		3.29	3.07	- 7.17
P		.64	.60	- 6.67
K		.70	.65	- 7.69
Ca		.94	.90	- 4.44
Na		.28	.28	0
Mg		.14	.10	-40.00
Fe	ppm	156	350	+224
Al	ppm	106	190	+179
Cu	ppm	138	100	-38.00
Mu	ppm	86	65	-75.58
Zn	ppm	105	65	-61.90

Table 5. A Comparison of Elemental Concentration of Company A's Broiler Feed and Corresponding Litter (Dry Basis)

Element		Ration	Litter (4 flock)	Degree of Concentration[1]
N	%	3.07	3.46	1.13
P	%	.60	1.25	2.10
K	%	.65	1.91	2.94
Ca	%	.90	1.97	2.20
Na	%	.28	.60	2.34
Mg	%	.10	.37	3.65
Fe	%	.035	.12	3.40
Al	%	.019	.07	3.64
Cu	ppm	100	293	2.95
Mn	ppm	65	183	2.81
Zn	ppm	65	173	2.64

[1]Ratio of concentration in litter to diet.

Table 6. A Comparison of Elemental Concentration of Company B's Broiler Feed and Corresponding Litter (Dry Basis)

Element		Ration	Litter (4 flocks)	Degree of Concentration[1]
N	%	3.07	3.22	1.05
P	%	.63	1.65	2.62
K	%	.79	2.41	3.05
Ca	%	.79	2.04	2.58
Na	%	.21	.61	2.92
Mg	%	.12	.44	3.64
Fe	%	.020	.20	9.62
Al	%	.017	.21	12.04
Cu	ppm	102	388	3.78
Mn	ppm	84	375	4.46
Zn	ppm	117	348	2.97

[1]Ratio of concentration in litter to diet.

SUMMARY

Precise information about litter composition is crucial to meet soil nutrient requirements when preparing nutrient management plans and preventing pollution. Various factors affect the proximate components of poultry litter. Due to those factors and their interacting effects, it is difficult to predict the composition of litter or manure. Learning more about those factors influencing the chemical composition of poultry manure and litter would allow their utilization to be considered in other areas of management and related activities.

If poultry litter is to be utilized for its nutritive value for plants or animals, it is recommended that each batch be chemically analyzed.

REFERENCES

Eno, C. F., 1962. Chicken manure: its production, value preservation, and disposition. University of Florida Agr. Exp. Sta., Circular S-140.

Payne, V. W. E., and J. O. Donald, 1991. Poultry waste management and environmental protection manual. Alabama Cooperative Extension Service, Circular ANR-580.

Vandepopulier, J. M., J. J. Lyons and C. D. Fulhage, 1992. Broiler litter sampling reveals needed information. Poultry Digest, August, pp. 14-18.

Vest, L. R., and J. H. Dyer, 1993. Many factors affect broiler litters mineral composition. Poultry Digest, September, pp. 30-32.

WHY AND HOW COMPOST WORKS

Lewis E. Carr
Extension Agricultural Engineer
Department of Agricultural Engineering
University of Maryland
College Park, MD

Composting of organic waste has been used for centuries. Its use in sewage sludge stabilization increased in the 1970's and 80's as alternatives to land fill, ocean dumping and incineration. As municipalities face disposal problems for their organic materials, so do food processors and farmers. This presentation will be limited to discussing the why's and how's of composting as it applies to poultry processing, primarily to hatchery and dissolved air flotation residues.

WHY COMPOST WORKS

Composting is a biological process of decomposing organic materials into a humus like product. The process will occur naturally, but can be "speeded up" and controlled if proper ingredients are blended together. The controlled composting process is usually considered an aerobic process, which requires oxygen.

HOW COMPOST WORKS

In order to generate a healthy compost process, five key elements are needed. They are as follows: a proper nutrient mix; moisture; oxygen; temperature; and pH control.

A proper nutrient mix is often referred to as the recipe; this is a blending of carbonaceous and nitrogenous materials together to form a desired carbon:nitrogen ratio (C:N). The ratio may vary from 20 to 35:1. Lower C:N ratios will produce rapid activity at the beginning, however, more odors will be given off in the process. A C:N ratio of 20:1 should be considered the minimum in formulating compost mix recipes. To assist in "recipe making" Brodie, 1994, at the University of Maryland, developed a computer spread sheet. The spread sheet allows the user to select the organic material(s) to be composted, then the program will indicate least cost recipe(s) based on the carbon sources available. Many scenarios can be evaluated, and a compost mix selection made in a very short period of time. A proper recipe is very important to successful composting.

Moisture in the range of 40-60 percent is acceptable for composting. There are times when the moisture will be at the extremes of the range. In research at Maryland, 50 percent moisture has worked well in our composting efforts. Without a scale and convective or microwave oven, how can the moisture be estimated in a compost mix? One field method is the hand squeeze test. In the hand squeeze test, a hand full of the compost mix is obtained and squeezed into a ball by forming a fist. One or two drops of water may be squeezed from the ball. As the fist is released, the ball should expand but remain intact. The hand will be moist by not too wet. The squeeze test, as described, will approximate 50 percent moisture in the compost mix. Moisture levels greater than 60 percent may also cause a supernate (liquid) to leach from the compost mix and cause anaerobic (odor-causing) and other undesirable situations. Moisture is a key ingredient. If the moisture is too low or too high, the composting process will not function properly.

Oxygen is required to maintain the composting process in an aerobic state. It is desirable to maintain aerobic conditions for odor control and multiplication of thermophilic bacteria associated with this process. As the oxygen is depleted, one of the indicators may be the lowering of temperature in the compost mix. However, measuring the oxygen content of the compost mix is a more reliable way to determine oxygen depletion. In compost mixes having very high BOD_5 loads, oxygen requirements will be great. It may not be possible to supply the oxygen requirements by just turning. To overcome this situation some systems may be aerated with a fan and piping system or a combination of mechanical and aerated systems.

Temperature is generated in a compost mix by the metabolism of the microorganisms. If the recipe, including proper moisture and oxygen, has been blended together correctly, the microbes will begin the metabolism process. The bacteria associated with the process are mesophilic (moderate heat loving) and thermophilic (high heat loving) species. Mesophilic bacteria operate at temperatures less than 110°F.; thermophilic bacteria operate at temperatures ranging from 110° to 150°F. Good composting temperatures range from 135° - 140°F. Composting temperatures of 150°F for organics from poultry are desirable to assure the destruction of pathogenic bacterial and viral organisms.

pH is another item that may be critical at times, particular if it exceeds 8. If a compost mix has a pH of 8 or greater, ammonia (NH_3) volatilization may become a problem as it will cause odors. The desirable pH range is between 5.5 and 7.5. In some processes, depending upon the material, the pH will decrease over time to approximately 7; in others the pH will increase. You have to be on the guard for shifts in pH. If the pH is out of the desirable range, appropriate chemical action to alter the pH may be desirable. If the pH is too high, blending ferrous sulfate into the compost mix has been found to be an effective pH control agent (Carr and Brodie, 1992).

COMPOSTING TECHNIQUES

Four composting techniques will be discussed. These techniques will "speed up" the composting process over natural composting. The techniques are: static pile; aerated static pile; windrow and in-channel.

Static pile is where the compost mix is piled and not disturbed for a long period of time. It may be turned, but not frequently. To assist in natural aeration, the initial compost mix should have a porosity of approximately 30 percent or use a bulk density of approximately 900 lb./yd^3.

Aerated static piles can be active or passive in mode of operation. The active piles normally draw air through the compost mix by using pipes or plenums placed in the compost mix and fans attached to the duct system. Air discharge from the fan system can be filtered through a biofilter for odor control. Another aerated pile system is passive in operation. The passive system uses a series of perforated 4 or 5 inch plastic pipes underneath the compost pile. The pipe ends are left open and a natural convective process provides oxygen to the compost mix. A porosity of approximately 30 percent or use a bulk density of approximately 900 lb./yd^3 is also desirable for the aerated pile system.

Windrow composting can be accomplished outside or in a large, covered structure. Windrows are normally turned with some type of turning equipment. The equipment can be as simple as a front end loader or self propelled equipment that straddles the windrow and turns it in one pass. However, good mixing may not be as effective with the front end loader is the turning device. A porosity of approximately 30 percent is desirable or use a bulk density of approximately 900 lb./yd^3.

In-channel techniques primarily use a turning device that runs down a rail of some type. It is possible to have parallel bays with common walls so the turning device can be moved from bay to bay. This type system is expensive, but may be a better system for long term composting. The in-channel system may also be used in conjunction with an aerated system. Fans and air ducts are placed through out the system and will speed up the composting process by continuously providing oxygen to the compost mix. This may be of great benefit if the compost mix is highly volatile. Air from the fans can be discharged into a biofilter for odor control. A 30 percent porosity or use a bulk density of approximately 900 lb./yd^3 will also assist in this process.

QUALITY CONTROL

Thought must be given to the compost product use before developing the initial compost mix. The end product will be no better than the feed stock used to make the initial mix. Therefore, it is very important to have a reasonably current nutrient analysis of each feedstock used in "recipe making". Tables 1 and 2 illustrate nutrient parameters associated with hatchery and dissolved air flotation (DAF) compost mixes (Carr and Brodie, 1992).

A decision has to be made concerning end use and compost quality. If the compost is going to be used as a field manure source, the refinement or quality of feedstocks does not have to be as great as that used in home landscaping.

To assist in determining if compost is cured, respiration rates of the compost can be determined by laboratory procedures. A field determination can be made by collecting a compost sample, saturating it with water (but not soaking, dripping wet), place in a sealed plastic bag and store in a warm place (70 - 85°F) for one week. After one week open the bag, if there are no bad odors, the compost has stabilized.

Table 1. Hatchery Compost Composition (wet basis - WB

Item	TKN %	Moisture %	Total Solids %	Carbon % (DB)*	pH	Bulk density lbs/ft^3
Wood shavings	0.01	18.62	81.38	55.29	5.5	8.36
Centrifuged hatchery waste	1.61	24.51	75.49	21.96	8.6	48.00
35 day-compost	1.19	25.01	75.99	31.34	8.4	22.10

*Dry Basis

Table 2. Selected Ingrdient and Compost Mix Parameters for DAF Compost (wet basis)

Item	TKN %	Moisture %	Total Solids,%	Carbon % (DB)*	pH	Bulk density lbs/ft^3
DAF skimmings	0.75	80.0	20.0	55.1	5.42	56.5
Broiler litter	2.44	30.0	70.0	48.27	8.29	30.1
Sawdust	0.47	48.6	51.4	54.36	5.5	26.0
Initial compost mix	1.53	56.9	43.1	50.78	7.85	38.0
Finished compost	1.90	43.6	56.4	50.50	7.60	25.5

*Dry Basis

Quality compost will have a C:N ratio of about 15:1. The time to achieve quality compost will depend on the technique used to compost. It may take one year or more to achieve a quality compost using static piles, whereas, a quality compost may be achieved in 2-3 months using mechanical systems.

SUMMARY

A brief overview of why and how compost works has been presented in this paper. The final compost will be no better than the initial mix of feedstocks and the practices utilized during the process. Current nutrient analyses of the feedstocks are necessary in formulating the initial mix recipe. Refinement or feedstock quality of a compost mixture will be determined by its end use.

REFERENCES

Brodie, H.L. 1994. Multiple Component Compost Recipe Maker. ASAE Paper 94-3037. International ASAE Meeting, Kansas City, Missouri. June 19-22, 1994.

Carr, L.E. and H.L. Brodie. 1992. Composting Hatchery By-Products and DAF Skimmings. 1992 Midwest Poultry Federation Convention, Minneapolis Convention Center, Minneapolis, MN.

REVIEW OF DAF FLOAT HANDLING METHODS

John E. Starkey, P.E.
Director, Environmental Affairs
Hudson Foods, Inc.
P.O. Box 777
Rogers, AR 72756

The poultry industry has come under increasingly stringent environmental regulation in the past decade. One area of major impact has been more restrictive effluent limitations, whether a facility is discharging to a POTW or holds an NPDES permit. This, in turn, has caused the industry to ask for ever-greater performance from the most common type of primary treatment employed - the dissolved air floatation (DAF) unit. As a direct result of improved DAF efficiency, the quantity of DAF float material generated has increased.

DAF float - by its very nature - is a difficult material to effectively handle or process. While it does contain oils and protein, with some limited value, its primary constituent is water. Further, it can also contain chemical coagulants and/or flocculents which may limit the available handling methods. Further, it is subject to rapid rancidity, meaning the float material has to be handled fairly rapidly, or the difficulty of handling is compounded.

In the face of increased float material, and recognizing the problems associated with the material, the industry has devised a variety of methods for ultimate disposition. This paper will review the traditional methods utilized, and introduce one promising technology; and set forth some of the advantages and disadvantages of each. Methods reviewed include:

1. Land Application
2. Composting
3. Reclaiming as Feed
4. Hot Air Drying

Land Application

As indicated earlier, float material does contain constituents which have some value. With respect to land application, the most valuable portion of the float material is protein, or more specifically, the nitrogen contained in protein which can subsequently be utilized by crops as a nutrient source.

The most common method of land application is subsurface injection of wet, non-dewatered float material. There are, however, facilities that surface spread either dewatered or wet float followed by immediate disc-in. Although each of these methods will generate public odor complaints, the latter will result in a higher number of complaints. Land application is weather dependent; provisions for material storage during inclement weather is necessary.

Cost for land application varies throughout the poultry producing areas of the country, typically they range from $.08 to $0.15/gallon. However, initially capital cost is usually low since application is normally contracted with a vendor who actually owns the necessary equipment.

The use of land application avoids concerns that have been raised over coagulants used in DAF units. It can, however, spark significant public opposition, an extensive permitting and monitoring requirements.

Composting

Composting DAF float is almost a subset of direct land application. Certainly, it was born from the desire to avoid the "odor opposition" to direct land application. Using this method, the processor will compost float material at a single, remote location. The finished compost, a stable, earthy scent product, can then be re-utilized as a soil amendment while greatly reducing public opposition and objection. It should be also noted, however, that a significant portion of its nitrogen nutrient content- usually more than 50% - is destroyed by this stabilization process.

Litter or sawdust are the most commonly employed bulking agents. Some companies inject bacterial inoculant to more rapidly stabilize the product, and eliminate odors as quickly as possible. Typically, compost piles are turned after ten days to two weeks, at this point additional float material is added. This process will continue until the carbon source in the bulking agent is depleted. At that point, the compost is ready for land application. Cost for composting ranges from $.10 to $.18/gallon, largely depending on transport distance and whether any costs are recovered via sale of the compost. As with direct land application, most of this cost is as an operating expense as opposed to a capital cost.

Reclaiming As Feed

The major non-water components of DAF float, oil and protein, have a feed nutritional value. Since the industry is a large feed user, it is not surprising that the most common method of reclaiming this material is as a feed.

Initially, the industry favored blending float with other renderable items - most commonly offal. However, in recent years there has been a discernable shift toward rendering this product separately from offal. Now, it is often mixed with other low-value items - such as hatchery waste, deboned meat residue, dead birds, etc.- to produce a lower grade feed. The reasons for this shift vary from company to company,indeed, from complex to complex, but typically where this has occurred there is either a desire to produce a premium value pet food grade feed, or concerns about the impact of float on mixed product feed quality, or both. As of late, there has been considerable controversy regarding whether the use of common DAF polymers - notably polyacrylamides makes the material unfit for animal feed production. In any event, the current trend is toward handling float separately from higher grade offal products.

Float material is introduced into the rendering process in both wet and dewatered states. One of the preparatory dewatering methods typically separates the oil from the solids prior to final rendering. Both batch and continuous cookers are employed for rendering.

Costs for handling via byproduct recovery vary dramatically depending upon the amount and cost of dewatering, heating cost, the types of products produced and the end market for the product.

Hot Air Drying

In the past twelve months, two companies have introduced to the market dryers capable of taking wet float material and producing a heat-stabilized low moisture product in a single step. In other words, for a typical process or producing 12,000 gal/day of float or 100,000 lbs, a successful dryer will reduce this quantity by an order of magnitude - or to approximately 11,000lbs/day. The product from dryers can then go to the land application or feed production - or even into new markets such as fertilizer production.

In the case of both manufacturers, hot air, 500°F - 700°F, is introduced into a chamber with the float material. Flash evaporation of the moisture takes place, virtually removing the moisture. The key to this process is that it utilizes the air as the heat transfer media. Conventional cookers utilize steam through a steel shell - a shell that can become coated with float residue and therefore transfer heat less effectively.

These dryers are also amenable to float material that has been dewatered. Dewatering the float significantly reduces the amount of fuel required to produce the final dry product. At the current time, no processor has yet installed either of these dryers for float drying. As a result, true cost figures are not yet available.

CONCLUSION

The industry has devised a number of methods to handle DAF float material. Selection of a specific method is dictated by complex-specific requirements. Hot air drying may provide a new, lower cost alternative than current methods.

PROTEIN CONVERSION OF DAF BIOSOLIDS

Vernon D. Rowe, P.E.
ROWEnvironmental
15 Sun Hala
Pittsburg, Texas 75686

DAF Biosolids Generation

Essentially all poultry processing plants are required to provide treatment of process wastewaters. Depending on the required degree of treatment, systems most commonly include:

- Physical Systems
  - Primary Screens (flat bed shaker screens and/or internally fed rotary screens)
  - Secondary Screens (internally and externally fed rotary screens)
  - Gravity grease and solids separation
- Chemical Systems
  - Air flotation using ferric salts and polymers
  - Air flotation using sulfuric acid and polymers
  - Air flotation using acid, chlorine, and polymers
  - Air flotation using multiple polymers
  - Air flotation using natural flocculants and polymers
- Biological Systems
  - Anaerobic lagoons
  - Activated sludge
  - Biotowers

The vast majority of plants operating today utilize, as a minimum, a combination of physical/chemical components to provide treatment to levels generally equal to or better than the following values:

Parameter	Normal Minimum Treatment Level
BOD, mg/l	less than 400
TSS, mg/l	less than 250
Oil and Grease, mg/l	less than 100

These chemical treatment systems generate a float by-product called biosolids. The biosolids consist of a combination of fats, oils, greases, and solids that are removed from the wastewater. Depending on the design of the chemical treatment system, the biosolids contain 10 to 30 percent solids, with the remainder being free and entrained moisture. A typical processing plant with a wastewater flow of 1 mgd will generate 5,000 to 15,000 gallons per day of biosolids, depending on the dewatering capabilities of the flotation vessel.

Traditional DAF Biosolids Handling

The handling of DAF biosolids has represented a major environmental challenge for the poultry industry for many years. Until recent years, most chemical treatment systems operated utilizing ferric salts as the primary coagulants. Due to concerns with the impact of the ferric salts on the quality of finished products from the rendering of the biosolids, the majority of the biosolids have traditionally been handled as a liquid or solid waste, with the primary disposal methods being:

- Land application
- Landfilling
- Composting

In the cases where DAF biosolids have been rendered, the finished product quality has generally been significantly degraded, with a resultant loss in revenue.

Increased Rendering of DAF Biosolids

In recent years, major efforts have been made by the poultry industry to modify treatment methods and chemicals to produce DAF biosolids which can be successfully rendered into profitable by-product materials in the form of poultry fat and poultry meal. As a result of these efforts, a significant increase has been realized in the percentage of biosolids which are being rendered. For example, during the past four years the largest and fifth largest poultry processors in the United States have begun to render essentially all biosolids in lieu of land application which had been utilized previously. This movement to rendering, coupled with the fact that essentially all biosolids generated by poultry processors in Georgia and Alabama have been rendered for years, indicates that the majority of biosolids are now rendered and represent a potential revenue source rather than an environmental liability and cost.

Chemical Treatment Schemes

A review of rendering operations throughout the United States indicates that biosolids resulting from many different chemical treatment schemes are being successfully rendered. The known chemical schemes include:

- Ferric salts and polymers
- Sulfuric acid and polymers
- Sulfuric acid, chlorine, and polymers
- Multiple polymers
- Natural flocculants and polymers

As indicated, ferric salts and polymers have been the chemicals of choice for many years for the pretreatment of poultry wastewater. While many concerns have been raised over the years regarding the rendering of biosolids containing ferric salts, the fact is that these biosolids can be successfully rendered. The best example of this is the fact that for many years the biosolids generated by the majority of processors in Georgia and Alabama using ferric salts have been successfully rendered, with the finished products being sold back to the processors for use in feed production. However, the rendering of these biosolids decreases the quality of the finished product. More specifically, the finished products can not be sold as pet food grade which significantly reduces the potential revenues.

The use of sulfuric acid, i.e. acidulation, and polymers has proven very successful in reducing biosolids volume and producing a more easily renderable biosolids material. With the advent of developments in process control technology which allow improved control of process pH, acidulation to a pH of 4 (+/-) coupled with the use of single or dual anionic and cationic polymers produces biosolids which yield a high percentage of top quality poultry fat and a solid material which can be rendered without significantly degrading finished product quality.

One proprietary system which utilizes a combination of sulfuric acid, chlorine, and polymers reportedly produces a biosolids material which can be directly rendered with poultry offal without significantly impacting the finished product quality.

Many processors, including the largest in the United States, are utilizing multiple polymer systems, with and without pH

control, to produce "non-chemical" biosolids which can be rendered. In one case a processor has converted a major environmental management problem into a profitable by-product recovery opportunity by constructing a dedicated rendering facility to handle only biosolids.
Natural flocculants and polymers have been successfully utilized by several processors to produce renderable biosolids. For example, one processor has successfully utilized bentonite and polymer to produce a material which can be directly rendered with offal.

Treatment Impacts

The major driving force in the selection of chemical treatment schemes in the past has primarily focused on achieving the best treatment results, with biosolids quality being a secondary consideration. Due to this factor, ferric salts have been utilized extensively because of the excellent treatment results which can be achieved in the removal of both soluble and insoluble wastewater contaminants. However, as the environmental pressures of dealing with ferric based biosolids has increased, extensive efforts have been made to identify alternative chemical schemes which give adequate treatment results while at the same time producing biosolids which can be rendered. While treatment results vary from processor to processor depending on the characteristics of the raw water supply, the type of treatment system utilized, and the degree of operator attention and skill, it has been successfully demonstrated that adequate treatment can be achieved with many different schemes other than those based on the use of ferric salts. In general, the following levels of treatment can be achieved from the numerous chemical schemes that are commonly used by the industry:

Chemical Scheme	BOD, mg/l	TSS, mg/l	O&G, mg/l
Ferric + Polymers	<250	<150	<50
Acid + Polymers	<350	<150	<50
Acid + Cl2 + Polymers	<200	<150	<50
Multiple Polymers	<300	<150	<50
Natural Coag + Polymers	<350	<150	<50

Thus, the presence of ferric salts in biosolids does not have to be a hindrance to biosolids renderability.

Biosolids Rendering Methods

There is no consensus as to the best method for the rendering of biosolids. Biosolids generated from each of the chemical schemes previously discussed are being successfully rendered using all of the following methods:

- o Direct rendering with offal
- o Separate rendering in dedicated facilities
- o Heat treatment and centrifuging with solids split rendering with offal
- o Preheating, evaporation and direct rendering with offal

The major issue which separates the success and benefits of these different rendering approaches is the quality of the finished products, as follows:

- o Biosolids which contain ferric salts can not be successfully rendered to produce pet food grade finished products. However, ferric based skimmings can be successfully rendered to produce feed grade products.

- o Biosolids generated with the use of acidulation, acidulation and chlorine, multiple polymers, or natural coagulants can be successfully rendered with offal to produce pet food grade finished products if the biosolids are rendered immediately, i.e. within four to eight hours, and the ratio of biosolids to offal is not excessive.

- o Biosolids generated with all common chemical schemes can be heat treated and centrifuged to produce a top quality poultry fat. The solid material from the centrifuge can be directly rendered with offal, but may cause quality pet food grade quality problems if the ratio of solids to offal is excessive.

SUMMARY

In summary, there are many processors who are successfully rendering biosolids generated from a wide variety of treatment systems and chemical schemes. While each situation has to be evaluated individually, the opportunity for biosolids rendered should always be evaluated in lieu of disposal methods such as land application, land filling, or composting. The past concerns with the presence of ferric salts in biosolids should not be a hindrance to the consideration of rendering. Viable alternatives which can achieve the desired treatment objectives while producing a potentially valuable, renderable by-product are available and should be considered.

INCREASING SOLIDS CONTENT OF DAF BIOSOLIDS

Matthew Hopkins
Director of Field Operations
Water Specialists, Inc.
P. O. Box 7417
328 Wallace Road
Marietta, GA 30065

It is desirable to produce DAF biosolids with a high solids content. High solids content DAF biosolids reduce transportation costs of hauling this material to rendering and evaporation costs to render the product. The goal of rendering is to produce a dried product by cooking the water from processing waste products. When solids are maximized less water must be evaporated from the raw product.

Table 1. Tons of Water Evaporated to Recover One Ton of Solids

Percent solids in DAF Biosolids	Tons of water evaporated to recover one ton of solids
5%	19 tons
10%	9 tons
25%	3 tons
50%	1 ton

From the data in Table 1 it is easy to see that increasing the solids content of DAF biosolids will decrease rendering transportation and evaporation costs.

Proper design and operation of the DAF system can significantly increase the solids content of DAF biosolids.

DAF Tank Design

1. The DAF tank should be of sufficient depth so that a DAF solids cap can build on the surface of the tank. When DAF tanks are too shallow it is difficult to build a DAF solids cap of sufficient depth to permit dewatering without the effluent shearing floc from the

bottom of the cap and increasing suspended solids concentrations discharged in the effluent.

2. Sweeps should be installed to remove DAF biosolids in the same direction as the wastewater flow through the tank. Using this method, the DAF cap can build and gravity dewater thereby increasing solids content. If sweeps run counter to the water flow through the DAF tank, wet solids that rise to the surface at the influent injection point will be removed before they have time to gravity dewater. A wetter DAF biosolids will result.

DAF Tank Operation

Many operators only look at the wastewater to determine if the DAF system is operating properly. The DAF biosolids cap should also be monitored to determine if conditions exist to maximize the solids content of the DAF biosolids. Conditions of the plant effluent vary throughout the processing day. DAF operational procedures should be adjusted to meet these changes.

Two types of air injection systems are common in DAF pretreatment systems.

1. Full pressurization systems recommend 40 psi pressurization, however, excessive air in the DAF biosolids reduce its ability to dewater. Excessive air causes a frothy floc with increased volume. The solids collection area of the DAF tank fills more rapidly and must be skimmed before the biosolids have an opportunity to gravity dewater. The bubbles of the frothy floc tie up more water and produces a wetter biosolids. To produce a high solids content material only enough air should be used to cause floc flotation.

2. With pressurized recycle DAF systems, the recycle and polymer injection points are critical. Polymer should be injected past the recycle injection point. Polymer injection before the recycle injection point shears the floc due to the high velocity of the recycle water being added to the plant effluent. Wastewater should be handled as gently as possible after polymer addition to maintain floc integrity and, thereby produce a drier, higher solids content DAF biosolids on the DAF tank.

Each plant is different. Operators should study the waste stream and its variations during the day. They can then develop the most appropriate pretreatment scheme to produce a high quality effluent and high solids content DAF biosolids.

FUTURE OF LAND APPLICATION FOR DAF BIOSOLIDS RECLAMATION

James H. Freiss, P.E.
Manager of Environmental Engineering
Continental Grain Company
3700 Crestwood Parkway, Suite 1000
Duluth, GA 30136

Lee J. Beetschen, P.E.
CABE Associates, Inc.
144 South Governors Ave.
Dover, DE 19903

Much of the pioneering work on treating and disposing of fats, oils & greases (FOG) from poultry processing facilities was done in the late seventies and early eighties. This portion of the paper discusses efforts by two integrators to develop cost effective, environmentally sound methods of dealing with FOG. One of the integrators had two facilities with operating Dissolved Air Flotation (DAF) systems. One had been installed to meet municipal pretreatment limits. The other DAF unit was located at a recently acquired facility. It served as pretreatment for an activated sludge system. The material being produced from these two units was considered unsuitable for rendering for several reasons. The in-house renderer found the quality of the end product to be unacceptable because of the high fatty acid content. Further, it was not cost effective to treat the material due to the high (93%) water content. Finally, the buyer would not purchase a rendered material which contained a metal salt coagulant.

At the integrator's third facility it was decided to use an anaerobic lagoon for pretreatment so that DAF sludge disposal would not be required. That same anaerobic lagoon was used to dispose of the DAF material from both of the other facilities for more than a year while alternate disposal methods were being evaluated. This practice was accepted by the state regulatory agency because it allowed an odor preventing cover to be established more promptly than would have occurred under normal operation.

The DAF sludge, being produced at 1.7 million gallons annually, contained about 1/3 chicken fat and 2/3 proteinaceous material. A typical chemical analysis is shown in Table 1.

Table 1. DAF SLUDGE ANALYSIS

Item	Concentration (typical) Wet Basis	Dry Basis, mg/L
Solids	15.0%	0.0
Nitrogen, Total	0.8	55,000
Phosphorus, As P_2O_5	0.223%	15,410
Potassium, As K_2O	0.080%	5,520
Copper	0.0008%	53
Cadmium	0.00001%	1.2
Lead	0.00007%	5.2
Zinc	0.004%	280
Aluminum	0.08%	5,500
Oil and Grease	6.6%	453,500
pH	5.5	---
COD	287,000 mg/L	---

The following treatment and disposal options were considered:

- Direct Land Application - Spread and Disk
Inject
- Land Application after Pretreatment - Blend with Waste Activated Sludge/Digest
Chemically Breakdown Fat and Digest
Use Liquid and Dry Enzymes for Fat Stabilization
- Landfill - Chemical Conditioning/Plate Press Dewatering
- Dedicated Lagoon Storage
- Stabilization by Vermiculture

The other integrator had a poultry processing facility in the mid-atlantic area remote from it's other operations. This facility was processing 125,000 birds per day but had serious odor and NPDES compliance problems. Although it too had an existing dissolved air flotation unit, that system was being used to remove algae and solids from the effluent from a aerated lagoon system and was not producing fats, oils and greases for disposal at the time.

Several alternatives were dismissed very early in the evaluation period. In the Dedicated Lagoon option it was intended that a series of earth works cells be constructed and filled with untreated primary sludge. Any liquid which separated from this sludge would be decanted and returned to the waste treatment facility. When one cell was filled, the next cell would be activated. Filled cells would be checked annually to determine their state of stabilization. It was anticipated that at some point in time the material would be stable enough to allow removal and land application without odor problems. Because of the uncertainties in predicting how long it would take for this to occur, and because of the potential for odor problems while being stored, this option was dismissed from further consideration.

Just about the time the alternative evaluation work was beginning, a value added processor in a nearby state began to independently examine the Chemical Conditioning Plate Press option. They undertook a concurrent study of the use of worms (Vermiculture) to further stabilize the material and produce a valuable fertilizer end product. They were gracious enough to share their findings. The land filling option was too expensive in terms of the cost of chemicals, capital investment in the plate press and the tipping fee at the land fill. Vermiculture was dismissed as being impractical for the integrator's purposes.

Only the Land Application options remained. Land application of this type of sludge was not a generally accepted practice at the time this research was being conducted. A great deal of regulatory staff education would be necessary if any of the options were to be implemented. Therefore, it was decided that two universities would be retained, one in each of the two states in which the programs were being considered, to lend third party objectivity to the work.

The Maryland Department of the Environment accurately considered the material to be raw sludge and refused to issue a permit for its general application. The University of Maryland Department of Agricultural Engineering therefore went on to perform the evaluation at a pilot scale on a two acre site over a four year period. Two nitrogen equivalent application rates were selected, 40 lbs. per acre and 140 lbs. per acre. With the control plots, the application rates for commercial nitrogen ranged between 135 and 157 lbs per acre measured as ammonia and nitrate. Carr et al. (1988) concluded that corn can be successfully grown with DAF sludge as the only nitrogen source at the application rates shown with no heavy metals accumulation in the plants and no buildup of nitrate in the water table.

The staff at the Agricultural Engineering Department of the University of Delaware did their evaluation of land application of the primary sludge at full scale on soybean plots over a two year period. Loading rates of 150, 300 and 600 lbs. of TKN per acre were used. In his interim report, Ritter (1981) concluded "the dissolved air flotation sludge applied at rates of up to 600 lbs. TKN per acre (sic) has no adverse effects on groundwater quality or soil properties. The sludge may increase the permeability of the soil".

Ritter was also retained to evaluate the use of liquid and dry enzymes for fat stabilization and for determining the feasibility of using chemicals for the same purpose. This work was completed prior to determining that the material could be directly applied without damage to the crop or the environment. Ritter's findings (1980) are of some historical and scientific interest. He tested 12 enzymatic materials and found two that produced a significantly greater oil and grease reduction than the control system, which was aerated for the same period of time. There appeared to be no cost incentive for their use.

Hydrogen peroxide, potassium permanganate and sodium hydroxide were used to chemically treat the sludge. The sodium hydroxide was ineffectual. Hydrogen peroxide and potassium permanganate achieved FOG reductions of 74% and 76%, respectively, but at a cost of 18 times that of the most effective enzyme.

In December of 1980, a grant was obtained from the Department of Energy to evaluate the final pretreatment option. The purpose of the grant was to demonstrate that primary and waste activated sludge could be economically converted to fuel and storable fertilizer through anaerobic treatment. At the time, Delmarva's annual broiler production was 420,000,000 birds. It was estimated that over 6,000,000 gallons of oil was being consumed annually for the steam used in the Delmarva poultry processing industry. Based on the estimates of the anticipated gas production, a 25% reduction in the quantity of oil required was projected. Gas was produced but the project was terminated when it became clear that land disposal was a viable option. The anaerobic system would have been very capital intensive.

A successful full-scale demonstration of the feasibility of gas production from a poultry processing wastewater treatment facility occurred at the second integrator's facility. An anaerobic lagoon was selected to provide both flow equalization and pretreatment. It was deemed to be more energy efficient than dissolved air flotation and to require no routine maintenance. Because of the owner's extreme sensitivity about odors, it was decided to cover the anaerobic lagoon with synthetic material. This was the first demonstration of methane gas recovery for poultry wastewater. The lagoon produced methane gas with a fuel value equivalent to approximately 250 gallons of Number 4 fuel oil per day.

Land application of untreated DAF sludge by the first integrator, which began in 1979, has continued unabated for 15 years. This program was to have been a stop gap measure until something better came along. All six of their processing facilities which have DAF pretreatment land apply the recovered material.

A survey was conducted to determine what disposal and recycling methods were most popular in the rest of the industry. The majority (80%) of 63 poultry processing facilities surveyed in 1994 are rendering their DAF solids. Only 3% reported stabilizing the material by composting. The balance, which includes the cited integrator, are continuing to land apply. However, five of the nine companies queried indicated environmental pressures, mainly the potential for odor, were the reason for the unpopularity of this method of recycling the nutrients in this material. In fact, 98% of the facilities indicated they would be out of the land application business for DAF solids within the next 5 - 10 years. Clearly, recycling by rendering or drying to create a feed ingredient is the direction in which the industry is headed.
The survey results showed just the opposite for waste bio solids. Eight integrators reported their disposal methods for 40 facilities. Of these, 40% land apply and 43% believe they will be land applying in the next 5 - 10 years. However, most were apprehensive about future regulatory pressures on land application and non-point runoff. Recycling by drying or rendering was the preferred alternative. One respondent expressed concern that emphasis on converting waste into feed ingredients might lead to more regulation as the public expresses apprehension over the practice.

In summary, it appears that the poultry industry is voluntarily moving toward rendering and drying and away from land application as the means of dealing with solids recovered from dissolved air floatation pretreatment at poultry processing facilities. On the other hand, if there is no significant change in regulatory practices, it appears as if there will be a moderate growth in the use of land application for the disposal and recycling of the nutrients from waste biological solids.

REFERENCES

Carr, Lewis E., Ralph C. Moore, William C. Merka, Franklin D. Schales, 1988. Land Disposal of Dissolved Air Flotation Sludge from Poultry Processing, Transactions of the ASAE, Vol. 31, No. 2, pp. 462-465.

Ritter, William F., 1980. Biological and Chemical Treatment of Poultry Processing Sludge, Technical Report, Department of Agricultural Engineering, University of Delaware, Newark, Delaware 19711, June.

Ritter, William F., 1981. Land Disposal of Poultry Processing Sludge, Interim Report, Agricultural Engineering Department, University of Delaware, Newark, DE 19711, January.

PRACTICAL APLICATIONS OF STORMWATER MANAGEMENT

Roosevelt Childress
Chief, Storm Water & Municipal Permits Unit
U.S. Environmental Protection Agency, Region IV
Water Management Division
345 Courtland Street, N.E.
Atlanta, GA 30365

The Federal Water Pollution Control Act of 1972 (FWPCA), amended to become the Clean Water Act (CWA) in 1977, required that EPA regulate "concentrated animal feeding operations" (CAFOs). Although most animal feeding operations were traditionally considered to be nonpoint sources of pollution, Congress defined CAFOs as point sources in the FWPCA. EPA established regulations under the National Pollutant Discharge Elimination System (NPDES) permit program which require permits for CAFOs that discharge to waters of the U.S. at times other than the event of a 25-year/24-year storm, and that (1) have more than 1,000 animal units (AUs) or (2) have more than 300 AUs and discharge directly to waters of United States; 40 CFR 122.23. The regulations define 1,000 AUs equal 55,000 turkeys; 100,000 layers or broilers if the facility has continuous overflow watering; or 30,000 layers or broilers if the facility has a liquid manure handling system; and, 300 AUs equal 16,500 turkeys; 30,000 layers or broilers if the facility has continuous overflow watering; or 9,000 layers or broilers if the facility has a liquid manure handling system.

Facilities in both categories are subject to penalties for any discharge to waters of the U.S. without a permit. Facilities in the first category shall not discharge to waters of the U.S. except in the event of a 25-year/24-hour storm. In addition, any facility may be required to obtain a permit if the NPDES permitting authority determines that the facility contributes significantly to pollution of a surface water. Permit conditions necessary to protect surface water quality may be included in any permit (U.S. Environmental Protection Agency, 1993).

The poultry concentrated animal production industry is identified under Standard Industrial Classification (SIC)

Code 025, Poultry and Eggs. Therefore, this industry is not subject to NPDES storm water application regulations, unless a particular facility is specifically requested to submit an application by the NPDES permit issuing authority. The poultry slaughtering and processing operations (SIC Code 2015), animal feed supplement and concentrate production facilities (SIC Code 2048) and rendering plants using poultry by-products (SIC Code 2077) are subject to the storm water regulations if they have conveyed storm water discharges from industrial activity areas to waters of the United States. Any poultry processing activities at a poultry CAFO will cause that activity to also be subject to the storm water permitting program.

The following discussion summarizes the NPDES storm water application and permitting program as it was developed and as it is being implemented.

The 1987 Water Quality Act amendments to the Clean Water Act added Section 402(p) to the Act which directed EPA to establish and implement a two phase NPDES storm water point source permitting program. To initiate this permitting effort, EPA published regulations on November 16, 1990 which defined the types of municipal and industrial storm water discharges that would be regulated under the first phase of the program, and which laid out specific permit application requirements. Storm water discharge monitoring requirements were an important part of the permit application process and will be an important component of NPDES storm water permits.

During the permit application process, storm water monitoring was required for regulated municipal separate storm sewer systems (MS4s) and storm water discharges associated with industrial activity. In general, the monitoring efforts yielded important information for NPDES storm water permit writers as well as for the permittees.

As a result of the monitoring efforts, EPA and the NPDES authorized States will be able to write tailored storm water discharge permits. Such information will also enhance a dischargers' ability to target pollutant sources when designing storm water management programs and pollution prevention plans.

Industrial storm water monitoring must be emphasized as a valuable tool for assessing the effectiveness of an industry's storm water pollution prevention plan and for examining possible receiving water impacts. With reliable storm water data, an industrial operator should be able to determine if current pollution prevention measures are adequate, or if additional measures, and possibly treatment controls, will be necessary.

The NPDES program provides three major tools for requiring and collecting monitoring data: permit applications; permit requirements; and information requests made pursuant to Section 308 of the Clean Water Act. Permit applications are generally national requirements which can provide a snapshot of the discharger once every five years. (NPDES storm water permits are usually issued with a five year term.) Monitoring data in permit applications is generally used for the purpose of supporting the issuance of the permit.

Although some monitoring requirements for NPDES permits are established in national regulations, such as the effluent guidelines, most permit monitoring requirements are established by permit writers on a permit-by-permit basis. This provides a great deal of flexibility to tailor monitoring requirements to each individual discharger. In addition, since permits are written for a five-year term, they can be used to require comprehensive monitoring programs that have the potential to evaluate discharge trends. Requests for information under Section 308 of the CWA are usually done more on an as necessary basis, and can provide a mechanism to fill some of the gaps associated with applications and monitoring requirements in permits or to answer other necessary permitting questions.

The NPDES program takes two very different approaches to controlling pollutants in storm water discharges. Under one approach, storm water requirements for industrial facilities are established in permits issued by EPA or by an authorized NPDES State. The second approach to storm water controls is through the involvement of municipal governments. Under this second approach, EPA or authorized NPDES States issue permits for discharges from municipal separate storm sewer systems which require the municipal permittee to develop and implement municipal storm water management programs.

One of the major differences between the industrial and municipal approaches is the programmatic flexibility available to develop monitoring programs. As discussed below, the NPDES program relies heavily on the use of general permits to authorize storm water discharges associated with industrial activity. In addition, industrial sites may be one of many sites in a watershed, or within a State, that discharges storm water. These factors tend to limit monitoring efforts to evaluating the nature of storm water discharged from a site and evaluating the effectiveness of the pollution prevention measures implemented at the site.

The NPDES regulations provided three different options for industrial facilities with storm water discharges to apply for permit coverage: individual applications; group applications; and submittal of a notice of intent (NOI) to be covered by a storm water general permit. Each option represents a distinct approach to collecting monitoring data.

Individual applications for most types of storm water discharges associated with industrial activity require site-specific narrative information, as well as monitoring data from a representative storm event. Individual industrial permit applications required monitoring for;

- Any pollutant limited in an effluent guideline to which the facility is subject

- Any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility has an existing NPDES permit)

- Oil & Grease, pH, BOD_5, COD, TSS, total phosphorus, TKN, and nitrate plus nitrite nitrogen

- Any pollutant known or believed to be present [as required in 40 CFR 122.21(g)(7)]

- Flow measurements or estimates of the flow rate, the total amount of discharge for the storm events sampled, and the method of flow measurements of estimation.

- The date and duration (in hours) of the storm events sampled, rainfall measurements or estimates of the storm event (in inches) which generated the sampled runoff, and the time between the storm event sampled and the end of the previous measurable (greater that 0.1 inch rainfall) storm event (in hours). In addition, individual applications must contain a certification that all storm water outfalls have been tested or evaluated for the presence of non-storm water discharges.

The Agency developed the group application process to lessen the monitoring burden on industrial facilities and to provide a large, nationally consolidated database of monitoring data from classes of industrial facilities. The group application process was intended to encourage similar types of industrial facilities to participate in the data collection effort, thereby compiling information on the class of facilities. EPA provided an incentive for industrial facilities to participate in a group application by only requiring a small percentage of the facilities in the group to monitor, provided the facilities were representative of the members in the group.

Over 65,000 industrial facilities representing 1250 groups initially participated in the group application process. Approximately 3,500 of these industrial facilities provided storm water monitoring data. This database represents the most comprehensive collection of storm water data from industrial facilities assembled to date.

The Agency is in the process of finalizing an innovative monitoring approach proposed in the multi-sector industrial storm water general permit based on the data received during the group application process. EPA used the data to identify pollutants of concern for each industrial sector and to select the most appropriate pollution prevention measures and BMPs.

Most storm water general permits for industry do not require monitoring data to be submitted during application coverage. General permits for storm water may identify targeted classes of facilities to conduct monitoring as a condition of the permit. Several factors have helped shape the approaches to developing monitoring requirements in permits for storm water discharges associated with industrial activity, including the large number of facilities that need to be covered by permits, difficulties in sample collection, and variability of data.

The NPDES regulations provide that permits for most types of storm water discharges associated with industrial activity must, at a minimum, require dischargers to conduct annual site inspections to identify sources of pollutants to storm water and evaluate pollution prevention measures. This requirement does not preclude the establishment of additional monitoring requirements on a case-by-case basis by the permit writer.

The baseline storm water general permit issued by EPA for industrial activities provide that most types of facilities do not have to conduct monitoring, but must conduct the annual compliance site evaluation. Under this permit, priority facilities that are thought to present higher risks have been required to conduct chemical monitoring of their storm water discharges in addition to conducting the annual inspections.

EPA has initially targeted classes of industrial facilities that need to conduct storm water monitoring on the basis of available information and best professional judgement. Monitoring requirements are intended to help regulators and permittees identify sources of pollution at facilities, evaluate the risk posed by the storm water discharges, evaluate the effectiveness of control measures and establish a database to support more applicable and effective permit requirements in the future.

For any NPDES permittee monitoring their storm water discharge, data collection procedures described in 40 CFR §122.21(g)(7) are required to be followed. Analytical methods are required to be conducted in accordance with 40 CFR Part 136.

Under 40 CFR §122.21(g)(7), specific storm event criteria were defined within which storm water sampling was required to be conducted:

> The depth of the storm must be greater that 0.1 inch accumulation
>
> The storm must be preceded by at least 72 hours of dry weather
>
> Where feasible, the depth of rain and duration of the event should not vary more than 50 percent from the average depth and duration.

These additional technical criteria were established to: (1) ensure that adequate flow would be discharged; (2) allow some build-up of pollutants during the dry weather intervals; and (3) ensure that the storm would be "representative," (i.e., typical for the area in terms of intensity, depth, and duration).

Collection of samples during a storm event meeting these criteria also ensures that the resulting data will portray more consistent conditions at each site. However, the permitting authority was authorized to approve modifications of this definition, especially for applicants in arid areas where there are few representative events. To support storm water monitoring requirements, EPA published a storm water monitoring guidance document that describes in detail the methods used for storm water discharge monitoring (Swietlik, et. al., 1994).

EPA is working with various animal producer associations to provide outreach to their membership. The outreach focuses on different means of encouraging environmentally sound management of their facilities to help eliminate associated water quality problems. Specifically for this industry, EPA entered into a cooperative agreement in 1991 with the Southeastern Poultry and EGG Association, the USDA Soil Conservation Service, and the Tennessee Valley Authority to disseminate information regarding water quality concerns to the poultry industry. These groups have formed what has become known as the "Poultry Water Quality Consortium," TVA-

HB2C, 1101 Market Street, Chattanooga, TN 37402, (615) 751-7297. The consortium has developed an educational display, conducted a water quality workshop in the summer of 1993, and is developing a comprehensive water quality handbook for the poultry industry (U.S. Environmental Protection Agency, 1993).

REFERENCES

U.S. Environmental Protection Agency, OWEC, September 1993, The Report of the EPA/State Feedlot Workgroup, Washington, DC, pp. 1, 2 and 136.

Swietlik, W.F., W.D. Tate, R. Goo and E. Burneson, 1994, "Uses of Storm Water Monitoring Data," Prepared for Conference Proceedings, pp. 2-8.

PRACTICAL APPLICATIONS OF STORMWATER MANAGEMENT

T. Eugene Newman
Director of Environmental Engineering
Tyson Foods, Inc.
2210 Oaklawn Drive, P.O. Box 2020
Springdale, AR 72765-2020

Storm water, although a natural phenomena, has been determined by EPA to be a major source of pollution in the countries streams, rivers and lakes. Congress has directed EPA to develop storm water management plans.

EPA and the various states have determined which SIC Codes could be polluters. If you are a processor of poultry, you fall into a SIC Code 20. SIC Code 20 is one of the regulated industrial classification. Some of the items required in the Storm Water Pollution Prevention sections of the Clean Water Act are:

1. Pollution Prevention Plans
2. Best Management Practices (BMP's)

When you get to the implementation phase of Best Management Practices you should already have been through:

1. A planning and organization phase
2. An assessment phase
3. A BMP identification phase

You are heading toward a monitoring and evaluation phase. The schedule for development and implementation of a storm water program is generally:

1. Plan Completion - April 1, 1993
2. Deadline for Plan Compliance - October, 1993

We have found that a team approach to BMP Identification and Implementation works very well. In general, our teams are comprised of:

1. Plant Manager
2. Maintenance Manager
3. Environmental Manager

4. Safety Manager, all members are from the local area.

One of the significant ingredients to a successful storm water program is management approval. The lowest management authority who can approve BMP's and their cost must be brought into the loop as early as possible. You don't want to devise a BMP then have to change it because of monetary restraints.

In addition to management participation, the other employees and supervisors at the facility should be taught about the program and how they will participate in its implementation. There are five major areas where programs and training should be completed:

1. Spill Prevention
2. Spill Response
3. Housekeeping
4. Material Management Practices
5. Auditing

We have found the information in the EPA Storm Water Guidance Manual to be very valuable in setting up the program.

PRACTICAL APPLICATIONS OF STORMWATER MANAGEMENT

Brenda B. Flick
Manager of Environmental Services
Sanderson Farms, Inc.
Post Office Box 988
Laurel, MS 39441

Practical applications used in the management of stormwater are basically what EPA is referring to as "best management practices". Best management practices are simply measures used to reduce the amount of pollution to the environment in the form of a process, activity, or a physical structure.

Sanderson Farms operations that are affected by the permitting requirements are the processing plants, feed mills, automotive and maintenance shops, and rendering plants. Sanderson Farms hatcheries, as well as our further processing plant which prepares frozen entrees and corn dogs, are exempted. The following paper will focus on the areas that Sanderson Farms has included in the Stormwater Pollution Prevention Plan, which is required in the general permits that have been issued by the State of Mississippi.

STORMWATER MANAGEMENT PRACTICES

Feed Mill Operations

1. Grain dust. Dust is created from the loading of feed trucks and unloading of rail cars. These are covered areas which minimize dust exposure, but do not completely eliminate the problem outside. These areas are either vacuumed or swept on a daily basis to reduce dust accumulation.

2. Fat storage tanks. Tanks are situated in secondary containments with locked drain values.

3. Liquid choline chloride and methionine storage tanks. Tanks are situated in secondary containments with locked drain values.

4. Diesel storage tanks. (Used as backup broiler fuel.) Tanks are situated in secondary containments with locked drain values.

5. Storage of chemicals and empty drums. Chemicals are stored inside the feed mill. Empty drums are picked up by the vendor; and since it is a low inventory item, these are also stored inside.

6. Trash dumpsters. Tops on the dumpsters are kept down.

7. Shavings (litter) storage. The shavings storage area is covered and has twelve-foot walls on three sides to prevent spilling over the sides.

Truck Maintenance Shops

1. Fueling operations. This includes the pumps and the storage tanks. Storage tanks are situated in secondary containment. Pumps are either exposed to the elements or under cover. The ideal situation is for fuel pumps to be under cover. A small amount of spilled diesel goes a long way. These areas are continuously monitored for good housekeeping practices to minimize spilled diesel accumulation.

2. Storage of hydraulic fluids and waste oil. These tanks are located out of the elements inside of the shop.

3. Wash bays for truck washing. All water inside of the wash bay is discharged to the sewer for treatment.

4. Oil filter disposal. Oil filters are drained, crushed, and disposed of in trash dumpsters. In the past, oil filters that were discarded would drain on the ground outside the dumpsters.

5. Used tire storage. Casings used for recycling are stored under cover. Scrap tire storage is also under cover. Whenever possible, we keep tire inventories to 25 tires or less. We pay a fee to have these tires picked up.

6. Scrap yard storage. Parts that are covered with lubricants are stored under cover. Scrap metal is stored outside until picked up by a recycler.

Processing Operations

1. Live haul sheds. Sheds are swept at least once a week and more frequently if needed. It is difficult to

sweep this area more frequently due to double-shift operations.

2. Refrigerated truck parking. This is a more recent improvement where trucks are parked in a paved, curbed area that discharges to the sewer for treatment.

3. Trash compactors. Compactors are in a paved, curbed area that discharges to the sewer for treatment.

4. Chemical storage and empty drum storage. Chemicals are stored under cover on pallets in order to prevent corrosion from exposure to inclement weather. Empty drums are stored on their side until they are picked up by the vendors. Drums that are not picked up by a vendor are crushed and disposed of in a landfill. We also buy in returnable tote tanks, which reduces the number of drums that need to be stored.

5. Shipping dock. Trucks back up to the plant to be loaded. This area drains to the sewer for treatment.

6. Receiving dock. Areas are under cover and drain to the sewer for treatment.

By-Products or Rendering Operations

1. Ingredient bins. Area originally discharged to the ditch. A pump was installed to catch the first flush. This pump also catches runoff from the processing plant, which reduces exposure of pollutants to the ditch. The area that drains to the pump can be washed down, which reduces pollutants to the ditch when it does rain.

2. Ramps to feather bins and meat bins. Truck tires are washed down prior to backing off of the ramps to reduce tracking of pollutants.

3. Fat tanks and blood tanks. These tanks are in secondary containments, which drain to the sewer for treatment.

All of the aboveground bulk storage plants are listed in the Spill Prevention Control and Countermeasure (SPCC) Plan. The SPCC Plan requires daily inspections of the grounds and weekly inspections of the tanks and containments. Any housekeeping problems noted in the daily inspections are corrected immediately. All inspections are documented and kept on file for three years.

There are only two areas where we have spent money to make improvements, the refrigerated truck parking lot and the trash compactor area. All other areas have continued to use good housekeeping practices and common sense as a mainstay to sensible control.

In conclusion, implementation of the Stormwater Pollution Prevention Plan has not been an insurmountable burden. The daily inspections for good housekeeping have been in place for as long as the SPCC Plans have been required. Prior to the annual stormwater inspections, each Sanderson Farms facility was audited annually. We are now required to submit an inspection form to the State, which is a simple one-page form. The Division Manager, Environmental Supervisor, or other designated individual participate in formal audits.

PRACTICAL APPLICATIONS OF STORMWATER MANAGEMENT

Carl A. Johnson, P.E.
Manager of Environmental Engineering
Perdue Farms Incorporated
Salisbury, MD 21802

The initial focus of the Clean Water Act of 1972 was to reduce the pollutants discharged from point sources of industrial process waste water and municipal sewage treatment facilities. The Water Quality Act of 1987 was enacted to continue the reduction in pollutant loading to receiving waters. The approach was to address industrial and large municipal stormwater discharges and the pollutants that they carry.

Strategies for complying with the regulations can be classified in three categories. The first strategy is to capture and treat all stormwater from the facility. This strategy allows the greatest control of all the stormwater discharges, which leads to a greater reduction in pollutant loading of the receiving waters. The disadvantages of this strategy include the need for capital to install structures to capture the flows, adequate organic and hydraulic waste water treatment capacity, and fairly high on-going treatment costs. The second strategy is to remove the pollutant from the facility so that all stormwater that is discharged is non-contaminated. The disadvantages of this approach include the labor and capital for clean-up, the uncertainty of compliance, and the disposal of the yard sweepings. An advantage of this strategy is that it has little impact on the Waste Water Treatment Facility of the Complex. The third strategy is a combination of both. This strategy allows one to combine the advantages of both strategies to arrive at the lowest cost solution. Examples of these strategies include:

- diesel fuel tank containment at a hatchery
- containment at a hatchery egg handling area
- containment for the capture of chick down from a hatchery
- vehicle wash facility containment area
- finished product refrigerated trailer storage area
- loading dock containment area

- vehicle garage oil storage containment area
- capital equipment required for yard clean-up
- clean-up labor

The program requires a Stormwater Pollution Prevention Plan for all applicable facilities. These plans must include a description of potential pollutant sources, site maps, topographic maps, and a narrative description of the facility. A Stormwater Committee needs to be formed in order to implement the requirements of the Stormwater Permit. Stormwater management controls include preventative maintenance, good housekeeping practices, spill prevention and response procedures, sediment erosion prevention, and management of runoff. Visual inspections need to be implemented in order to reduce the impact of stormwater. All records relating to this plan need to be retained for three (3) years. Please note that the Stormwater Plan may have some commonality with other plans, such as the Spill Prevention Control and Countermeasure Plan. It is also a requirement that the Pollution Prevention Committee conduct training and document such. It is very important to consider the membership of this committee, in that it must include a combination of senior facility management along with first line management to insure that the plants' practices are in deed carried out.

In the last two years we have made tremendous progress in the implementation of these stormwater regulations. The pollutant loading to the receiving streams from our facilities has been reduced. The creation of the Pollution Prevention Committee at all of our facilities is tasked with complying with the applicable regulations, and in this case reduce the pollutant loading from stormwater. The Pollution Prevention Committee, the stormwater regulations, and a positive proactive approach contributes to providing a safe and wholesome environment in which to live and work.

BURNING OR ANAEROBIC DIGESTION OF POULTRY MANURE TO PRODUCE ENERGY: PROS AND CONS

Herbert L. Brodie, P.E.
Professor
Department of Agricultural Engineering
University of Maryland
College Park, MD 20742

The idea of utilizing organic waste for the production of energy is neither new nor unique. Anaerobic digestion for treatment of municipal organic wastes with the utilization of the methane by-product for fuel has been practiced for over 100 years. Small methane systems utilizing animal manure are commonplace in India and the Far East. In the U.S. research efforts have occurred over the past 30 years to develop the process for adoption on large livestock and poultry farms. Thermal oxidation (burning) of animal manure for heat probably has a longer but less documented history. The most notable example in our culture is from the early Americans who burned buffalo chips in their campfires.

The interest in energy retrieval from organic wastes is cyclic. In each cycle we rediscover that there is energy to be retrieved; promote the idea; investigate applicable technologies and build some systems; find that something needs further costly research and that the process was more involved or more expensive than we had envisioned; and then go on to something else until the cycle starts again.

Economics is the driver of the cyclic process. After all, we are in business to make profit. We try to make income by growing chickens, or making energy, or researching for a university - we do not make profit with investments which cost more than they return. Cost may be influenced by world conditions (oil shortage in 1970's: glut in the 1990's), regulations (environmental and others), and technological advances. We search for the least cost, the greatest return and are quick to abandon investments that do not pay regardless of any promised long term non-economic benefit.

ANAEROBIC DIGESTION

An anaerobic digestion process converts organic carbon, oxygen, and hydrogen in the presence of nutrients to methane, carbon dioxide, water and other products through microbial activity in a free oxygen starved environment. The microbes are endothermic and require the addition of heat in order to maintain their activity. The methane produced in this process is a combustible gas which can be captured and used as a fuel for the production of heat or the operation of internal combustion engines. The heat or mechanical energy can be converted to electricity.

Biogas Plants

The production of biogas from animal manures is a proven process. The facility requirements can vary in design and application depending on the conditions of the manure and the site. A full description of the process can be found in many reports (Koelsch et al., 1989 and Parsons, 1984) and is not the purpose of this paper.

Biogas plants require liquid manure (less than 12 percent solids) to facilitate movement of the manure with pumps and in the case of poultry manure to dilute the nitrogen concentration for pH control. Only about thirty percent of the volatile solids in the manure is actually converted to biogas. More could be extracted but at the expense of longer hydraulic retention times which would require larger structures and excessive costs. There is practically no reduction of manure volume that must be stored, disposed or utilized after anaerobic digestion and the digested mass may be greater than the raw manure input if water was added.

Major nutrients, although included in the reaction, are not part of the biogas. The fertilizer content of the digested manure is similar to that of the raw manure, but some nutrients may be more plant available after digestion.

An important aspect of anaerobic digestion is that the process is carried out by living organisms. A biogas plant is in essence a structural cow which requires a consistent feeding program of balanced energy, nutrients, and water at an optimum temperature. Changing nutrient or pH conditions, introducing excessive amounts of antibiotics or toxins, losing heat resulting in temperature decline, over- or under-feeding, or any other deviation from required practice may reduce biogas yield or may cause total system failure.

The ability to utilize or sell biogas produced energy has a significant impact on the economics of the process. Biogas is utilized as a replacement heating fuel for boilers and furnaces or for the production of electricity through use as a fuel in an internal combustion engine which drives a generator. Only about 70 percent of the biogas produced can become useable heating fuel with the remainder being needed by the process. If electricity is produced, the marketable energy is from 20 to 30 percent of the biogas potential with the remainder lost as heat which can be reclaimed for the digestion process or other heating uses.

Biogas has a low energy density of 19 to 22 MJ/m^3 (500-600 btu/cf) and the most viable alternative is to consume the gas as it is produced. Because most situations do not have a consistent need for heat (other than that needed to maintain digester temperature) some of the heat may be wasted. Biogas can be compressed but not liquified at reasonable pressures and storage of biogas energy is volumetrically inefficient. One volume of diesel fuel holds the same amount of energy as 130 volumes of 1,380 KPa (200 psig) compressed biogas.

Most farms do not have a consistent requirement for electricity throughout the day or year. During low electric use periods some biogas produced electricity will be sold to the electric utility. During high electric use periods all biogas produced electricity may be used and possibly some utility electricity will be purchased. Usually electricity sold to a utility is priced at the replacement value of utility fuel which is only a fraction of the charge for buying electricity from the utility. The most valuable use of biogas produced electricity is for the avoidance of the high cost of purchasing electricity from a utility.

The net predicted economic return for biogas production and conversion to energy is highly dependent on the facility capital and maintenance cost, the use or sale of the energy, and the use or sale of the digested manure. The actual economic return is influenced by the degree of management and maintenance attention given to the details of operation.

Fate of Biogas Plants

Technical, managerial and economic problems have affected the adoption and survival of facilities utilizing anaerobic digestion of animal manures for the production of biogas. An estimated 60 percent of the biogas facilities constructed between the early 1970's and mid 1980's have ceased to operate (Koelsch, Lusk and Weeks personal communications). Technical design failed to provide reliable materials handling, heat transfer, and energy conversion equipment. Management failed to provide the required maintenance in a timely manner (Koelsch and Weeks, personal communication). Marginal economic return and reduced cash flow exacerbated the delayed maintenance activity which made failure more eminent (Lusk, personal communication).

There are an estimated 25 to 30 (3 poultry) biogas plants in operation across the U.S. today (Lusk, personal communication). These systems have been upgraded through investment in equipment and facilities to remain functioning. Management makes the system work and economic decisions are biased toward that commitment (Lusk, personal communication).

The economic return from the energy produced is marginal. Typically a term of seven to ten years has been required before energy income exceeds fixed and variable costs (Lusk, personal communication). However, well designed systems can be expected to have a useful life of fifteen to twenty years and would provide profitable operation for half of that life. This economic situation may be satisfactory on a farm which is intended to exist for a long number of years and can survive short term economic loss. However, investor capital requires a greater, more rapid rate of return which almost eliminates the feasibility of investor financed biogas facilities.

An investigation of the development of a centralized dairy manure processing cooperative showed that the ability to produce large amounts of energy did not improve the economic return (Brodie and Stevens, 1981). This has been proven correct in Oregon where a 10,000 cow biogas cooperative is currently undergoing reorganization with possibilities of failure as a result of marginal income. There appears to be no economies of scale associated with centralized systems (Lusk, personal communication). Increased manure procurement, transportation and management costs may exceed any reduction in construction and energy generating cost.

The most profitable biogas plant operators convert or utilize every possible part of the manure and energy into sales or avoided costs. Excess heat energy normally lost from the process is utilized in special ventures such as greenhouse or aquacultural heating. The liquid fraction from the digester is bottled and the solid fraction is dried using excess heat and bagged or composted for sale as fertilizer to urban gardeners. These activities require the development of specialized markets and additional investment but increase the economic return from the manure. It should be noted that these auxiliary enterprises often require as much or more management as the base animal enterprise.

There is a renewed interest in biogas production for environmental protection. Under this circumstance, system construction and operation is considered an environmental protection cost which alters the economic analysis such that the marginal return from energy may be more acceptable.

Anaerobic activity occurs in liquid manures with the release of odors during storage. The problem of odors is acute where liquid manure from a large number of animals is stored. Anaerobic digestion reduces the volatile components of the manure resulting in a treated manure which can be stored and later applied to cropland with reduced odor (Koelsch and Weeks, personal communications). Where odor control is required for the operation of the animal enterprise the production of energy may be of secondary importance. Some anaerobic digestion systems have been installed without the energy conversion component (Weeks, personal communication).

The U.S. Environmental Protection Agency (US-EPA) is concerned with the release of methane to the atmosphere. Methane is a greenhouse gas which could increase global warming. US-EPA's AgSTAR program promotes the installation of anaerobic digesters for the capture of methane from existing liquid manure storage and lagoon treatment systems (Roos, 1994). The methane must be utilized through conversion to heat or electricity or otherwise prevented from release to the atmosphere. US-EPA does not encourage the conversion from dry to liquid manure systems for the sole purpose of energy production (Steinwand, personal communication).

THERMAL OXIDATION

Dry manures can be burned either alone or with other fuels for the production of heat. The heat can be used for area temperature control, industrial processes, and generation of electricity. Manure has greater energy value as a direct burn fuel than as a biogas source because almost all of the energy in the manure can be released through burning. The amount of this energy actually captured is dependent on equipment efficiency and manure moisture content (Annamalai et al., 1987).

Broiler manure at 20 percent moisture produced a net heat return of 8.0 MJ/kg (3,500 btu/lb) when burned in a small down draft furnace Muir, personal communication). Heating values used in a consultants report (Kuljian Corp., 1987) for a large fluid bed burner were reported as 16 MJ/kg (6,900 btu/lb) for dry broiler liter and 8.3 MJ/kg (3,600 btu/lb) for dry layer manure (actual data source unknown). The variability of the reported energy content is not unexpected because of the known variability of manures.

On-farm use of heat energy from burning poultry manure is limited by the energy demand cycle and the design of small furnaces. Seasonal heating of the farm residence and animal structures could be accomplished. This may require only a small portion of the manure generated on the farm and may not be a solution the a waste disposal problem.

Burning raw broiler litter in small furnaces has presented problems of incomplete combustion, slag formation on the grates, odors, particulate emissions, and loading difficulties. A potentially difficult problem is that all of the nitrogen in the manure is volatilized into unknown forms for release as a stack emission (Muir, personal communication). Furnaces must be operated at high continuous temperatures to avoid some of these problems. Loading problems can be overcome with pelletizing the manure which, unfortunately, may require more energy than can be retrieved.

Manure can be used as supplemental fuel in large coal burning electric generation plants. Some electric companies have investigated using broiler litter with coal but have abandoned the idea for undisclosed reasons (Carr, personal communication). One reason may have been the inability to ensure a reliably large and inexpensive supply of manure when contracting with a large group of farmers on an individual basis.

Approximately 2.6 mass units of broiler manure at 30 percent moisture would be required to supply the same energy as one mass unit of coal. The bulk density of broiler manure is less than half the bulk density of coal. Therefore, 5 to 6 volumes of broiler litter would be required to replace the energy available in one volume of coal. Considerable change in materials handling and storage would be required to facilitate reliable use of broiler manure as a coal substitute. It is difficult to predict a savings for the utility when the amount of material to be handled must be increased by six fold unless the utility was paid to receive that material. Without the assurance of an economical and reliable broiler manure fuel supply the investment in changeover facilities is at great risk.

Broiler manure can be used as supplemental fuel in biomass burning facilities and waste-to-energy systems for burning urban garbage with little change in facility operation. Manure may be of value for improving the consistency of the energy content of the garbage mix in a waste-to-energy plant. These plants normally have exhaust scrubbing equipment so that nitrogen can be captured.

Inorganic ash from burning manure can be utilized as a soil amendment and may have some fertilizer value which can be used to generate additional income. However, mixed ash from waste-to-energy facilities requires disposal at approved landfills and generates additional cost. Because burning manure destroys organic matter the long term consequence may be a general reduction of agricultural soil organic content.

In addition to tipping fees, contracts with waste-to-energy facilities often require minimal energy production levels under which waste providers must pay for the energy not produced as assurance of profitable operation. With this arrangement some communities have had to buy garbage from other communities to maintain the contracted waste flow to avoid energy loss penalties. Farmers may not accept such a commitment to a manure dedicated waste-to-energy plant.

Fate of Mass Burn Plants

Although several poultry manure burning facilities have been proposed (Carpenter, Carr, Collins and Muir, personal communications; and Kuljian Corp., 1987) it appears that none have been constructed. The cost of manure collection and transportation combined with the unreliability of the supply, the desire from farmers to be paid for the manure, the relatively low heating value for the bulk, and predicted tighter regulation of exhaust emissions make the longevity of the investment questionable.

SUMMARY

The production of heat or electrical energy using poultry manure as a feedstock is feasible and technically possible. But, anaerobic digestion systems installed on farms for the production of methane from animal manures have suffered a 60 percent failure rate over the last 20 years and mass burn cogeneration facilities utilizing poultry manure have yet to appear. Investment in manure energy systems is stifled because the return to investment capital is low and over a long term relative to other investments of less risk. Energy technology is applicable to poultry manure where environmental or other external pressures prohibit adoption of less costly technologies for treatment or utilization.

REFERENCES

Annamalai, K., M.Y. Ibrahim and J.M. Sweeten, 1987. Experimental Studies on Combustion of Cattle Manure in a Fluidized Bed Combuster. Journal of Energy Resources Technology. Transactions of the ASME. 109/49 No.2.

Brodie, H.L. and G. A. Stevens, 1981. Methane Generation Through Farmer Cooperatives. Paper No. NAR-81-223. American Society of Agricultural Engineers. St. Joseph, MI.

Carpenter, G. Department of Poultry Science, North Carolina State University, Raleigh, NC. Personal communication

Carr, L.E. Agricultural Engineering Department. University of Maryland. College Park, MD. Personal communication.

Collins, E.R., Jr. Agricultural Engineering Department. VPI & SU. Blacksburg, VA. Personal communication.

Koelsch, R.K., E.E. Fabian, R.W. Guest and J.K. Campbell, 1989. Experience With Three Anaerobic Digestion Systems on Commercial Dairies. Paper No. 89-6550. American Society of Agricultural Engineers. St. Joseph, MI.

Koelsch, R.K., E.E. Fabian, R.W. Guest and J.K. Campbell, 1989. Anaerobic Digesters for Dairy Farms. Extension Bulletin 458. Department of Agricultural and biological Engineering, Cornell University, Ithaca, NY.

Koelsch, R.K. Agricultural and Biological Engineering Department. Cornell University. Ithaca, NY. Personal communication.

Kuljian Corporation, 1987. Lancaster County Conservation District Feasibility Study for Cogeneration Utilizing Poultry Waste as a Fuel Source. The Kuljian Corporation. Philadelphia, PA.

Lusk, P.D. Research Development Associates for the National Renewable Energy Laboratory. United States Department of Energy. Washington, D.C. Personal communication.

Muir, F. Poultry Science Department. Ohio State University. Columbus, OH. Personal communication.

Parsons, R.A., 1984. On-Farm Biogas Production. NARES-20. Northeast Regional Agricultural Engineering Service. Ithaca, NY.

Roos, K.F., 1994. The AgStar Program: Energy for Pollution Prevention. United States Environmental Protection Agency. Washington, D.C.

Steinwand, B. AgStar Program. United States Environmental Protection Agency. Washington, D.C. Personal communication.

Weeks, S.A., Director. Farm Systems Research and Applied Technology. AGWAY, INC. Syracuse, NY. Personal communication.

MANURE MARKETING: A TOOL FOR NUTRIENT MANAGEMENT ON POULTRY FARMS

Leon Ressler
Extension Agent, Lancaster County
Penn State Cooperative Extension
1383 Arcadia Road - Room 1
Lancaster, PA 17601-3149

Nutrient management legislation was signed into law in Pennsylvania in May of 1993. This bill requires that all animal operations with more than two animal units per acre (1000 pounds of live weight equals one animal unit) prepare and submit a nutrient management plan to their local conservation district for approval. A key part of the nutrient management plan for operations with surplus manure nutrients is determining how to utilize the excess manaure. Marketing of the manure to other agricultural operations which need crop nutrients is a strategy which can solve the surplus problem for many Pennsylvania poultry farms.

In order to promote redistribution of surplus manure nutrients, Penn State Cooperative Extension has developed a manure marketing program. This effort is focused in Lancaster County which is noted for intense poultry and livestock operations on small farms. Lancaster County farms are home to 8,982,000 layers and produce 44,500,000 broilers per year. Other livestock in the County includes 91,900 dairy cows, 164,100 beef cattle and dairy replacements, and 349,500 hogs (PA Statistical Summary, 1992-93). High land values have forced farmers to seek ways to increase income per acre. The solution chosen by many has been to increase animal units per acre and import purchased feed to the farm. Eggs, broilers and pullets are exported from the poultry farms but a surplus of crop nutrients remain behind in the form of poultry manures.

Increasing environmental concerns about agricultural nonpoint source pollution which provided the impetus for the nutrient management legislation makes it imperative that poultry farmers find ways to export their surplus manure for use off the farm. Since poultry manure is high in fertilizer value it is economically feasible to transport it to a distant buyer. Weaver and Souder (1990) reported that broiler litter can be economically shipped 100 miles for fertilizer use or 300 miles for feed supplement use in Virginia. Three Lancaster County firms are currently marketing a total of 55,000 tons of poultry manure per year, most of it out of the county. Numerous other poultry producers are marketing their manure surplus directly without the assistance of outside commercial firms. Some is trucked as far as 350 miles and still sold at a profit. Custom application of layer manure to buyers' fields is a growing service that is increasing market opportunities.

To participate in the extension manure marketing program, farmers completed a survey form indicating whether they were potential suppliers or potential receivers. Also included in the survey were questions relating to delivery and custom spreading ability, willingness to supply free manure, and availability of composted manure. The participants names were compiled into supplier and receiver lists which are organized by county and township. These lists are updated annually and sent out in March. The farmers on the supplier list receive a copy of the receiver list and vice versa.

As of March 1994 almost three times as many farmers have signed up to receive manure as to supply it (295 *vs* 113). This indicates a real marketing opportunity exists for those with excess manure nutrients. In this high livestock area the lesser number of those who signed up to supply manure is not an indication of limited supply but is probably a reflection of unwillingness of farmers who have excess manure to draw attention to themselves for fear of repercussions. Other producers choose not to participate because they already had developed their own marketing channels.

A summary of the survey indicates that among the suppliers, 25% are able to custom apply the manure, 13% are able to deliver the manure but not apply it, 33% are willing to supply the manure free if the receiver picks it up, and 3% have a composted product. Among the receivers, 27% are especially interested in compost, 49% are willing to pay for the manure, 39% are only interested if it is free, and 22% are only interested if the supplier can custom apply the manure. This indicates that poultry producers can increase the market opportunities for their manure by offering a composted product or custom application service. Answers to other survey questions indicate 34% have tested their manure nutrient concentration, 73% have never calibrated their manure spreader, and 13% regularly market manure to other operations.

Follow-up surveys were conducted in 1991 and again in 1993 to evaluate the effectiveness of the supplier/receiver lists in stimulating redistribution of manure. Seventy-three percent of the suppliers who responded to the 1993 survey reported using the lists to make contacts. Fifty-six percent of the suppliers reported being contacts by others on the list. Among the potential receivers, 60% reported using the list to make contacts, while 30% of the receivers reported being contacted by others on the lists.

More important in measuring impact of the manure marketing effort however, is the number of transactions which result from these contacts. Seventy-three percent of the suppliers reported making at least one transaction as a result of the contacts, 46% reported two to five transactions resulted, and 13% reported more than six transactions resulted. Among the receivers, 50% reported making at least one transaction and 20% reported two to five transactions.

In the 1993 survey, farmers on the lists reported supplying or receiving 19,040 tons of manure annually. Farmers on the lists surveyed in 1991 reported supplying or receiving 16,270 tons annually.

This effort is continuing as a part of Penn State Extension's program in Lancaster County, Pennsylvania.

REFERENCES

Pennsylvania Agricultural Statistics Service, 1992-93 Statistical Summary. National Agricultural Statistics Service, USDA and Pennsylvania Department of Agriculture, Harrisburg, PA.

Weaver, Jr., W. D. and G. H. Souder, 1990. Feasibility and economics of transporting poultry waste. Proceedings, 1990 National Poultry Waste Management Symposium, pp. 123-129. J. P. Blake and R. M. Hulet, editors. Auburn University, AL 36849.

Table 1. Results of the 1993 and 1991 Manure Marketing Mail Surveys

	0	1	2-5	6 +
1. How many times have you made contacts using this list?				
Supplier-93	27%	0%	53%	20%
Supplier-91	28%	14%	43%	14%
Receiver-93	40%	30%	30%	0%
Receiver-91	37.5%	31%	25%	0%
2. How many times have you been contacted?				
Supplier-93	40%	13%	40%	0%
Supplier-91	43%	7%	43%	0%
Receiver-93	40%	30%	0%	0%
Receiver-91	43%	25%	12.5%	0%
3. How many of these contacts led to making a deal?				
Supplier-93	20%	13%	46%	13%
Supplier-91	28%	36%	36%	0%
Receiver-93	20%	30%	20%	0%
Receiver-91	25%	50%	6%	0%

4. How many tons or gallons do you receive or supply annually?

Total exchanged 93 Survey 19,040 tons

Total exchanged 91 Survey 16,270 tons

Note: Answers given in gallons were converted to tons

[1--3: Answers expressed a percentage of those responding.]

WINDROW COMPOSTING POULTRY AND HATCHERY WASTE

Calvin J. Kuska
Kuska/Associates
8547 E. Arapahoe Road, Suite J-221
Greenwood Village, CO 80112

Composting is that ounce of prevention worth its pound of cure for the agricultural producer or processor of animal products. The degradation of water qualities, both rural and urban, along with the bacterial, nutrient and chemical contamination of water supply sources is becoming such a concern that problems will soon be regulated on a watershed rather than an individual site basis.

The problem by-products which are generated in the production of animals include manures, refused or spoiled feeds, mortalities, predatory animals, wash waters, wet or soiled, paper products, process sludges, hatchery egg trays, rotten eggs, throw-away organic items, etc. Anything that originated from the soil can and is being composted. In many areas of the World, we are helping farmers introduce to these streams urban source-separated organic wastes from lawn services, grocery stores and restaurants, wood products manufacturers, junk mail and other items to add to their recipe siding the composting process.

CRYPTOSPORIDIUM--A NEW SUPER BUG

The issue of nonpoint source pollution will be vital in the reauthorization of the Clean Water Act and the Resource Conservation and Recovery Act, because there have been too many notorious instances of bacterial pollution of public system drinking water like that in Washington, D.C. and Milwaukee. After one year there is so much concern about water safety in Milwaukee that 15% of 800,000 people required earlier to boil water for safety are still doing it, and 38% reportedly are purchasing expensive bottled water. Over 100 persons have died and 400,000 reported illness due to a waterborne parasite. Cryptosporidium, which is carried by human and animal wastes.

Ironically, the State of Wisconsin prepared an extensive study outlining the impact of livestock manures on water quality in the State in the early 1980's, but the Governor refused to release the report since it would impact the "America's Dairyland" license plate. As a result no preventative action or educational programs were undertaken, so the problem years later has become severe in nature.

Today, Wisconsin has undertaken the leadership for a nation-wide Farm *A* Syst program to preserve groundwater quality and protect farms from liability. The program is designed more to assess the problems facing agriculture than direct and educate about desirable type methods presently available for prevention. In the U.S. General Accounting Office's most recent report to Congress on Food and Agriculture issues, they state that "polluted runoff from agriculture affects 50 to 70% of the nation's monitored waters. Although the 1985 and 1990 farm bills created environmental and conservation initiatives, many challenges lie ahead because the initial lives are still in transition. Thus, new approaches that combine education, research, technical assistance, technological innovation, and regulation will be needed to sustain agricultural and environmental goals simultaneously."

SOIL IS NOT LIVING FILTER

The subsurface or land was traditionally viewed as having an almost limitless capacity to absorb, filter and attenuate waste materials entering it. So tenaciously was this belief held by the scientific and engineering communities that mountains of evidence to the contrary had to be amassed before this concept was finally discredited. One example of research, "The Effect of Farm Liquid Waste Application on Receiving Water Quality", conducted in Huron and Perth Counties, Ontario on five different soil types, found that bacteria at 11 liquid manure spreading sites can travel through the soil column and reach the tile water within a short period of time. In one case, that time period was as low as 20 minutes. Researchers of this study referenced other studies by Evans and Owens in 1972 and Patterson et al. in 1974, who both found tile drain water to be polluted a short time after the application of liquid manure.

The State of Washington Department of Ecology Shellfish Unit reported in January 1992 that failing septic systems and animal waste, respectively, causes 82% and 75% of the shellfish harvest restrictions in the Puget Sound. The basin encompasses 119 watersheds and involves more than 500 jurisdictions and agencies.

COMPOSTING--THE ULTIMATE FORM OF RECYCLING

Composting is increasingly seen as a vital form of recycling, of turning a previously landfilled or land disposed organic stream, into a useful soil additive to eliminate wetlands peat moss and replace or supplement chemical fertilizers and pesticides. Innovative and early adopter corporations and farmers are turning to composting for reduction, stabilization and safe and valuable utilization of the organic materials.

Even the topsoil issue is becoming more critical as reports from the United National Environmental Programme that the current global topsoil losses are estimated at 24 billion tonnes annually. In the U.S. Corn Belt, studies show that each inch of topsoil lost reduces crops by six percent. They also state, "there is evidence that a plateau has been reached in global efforts to increase the area under cultivation and enhance yields per hectare through agro-chemicals."

Studies conducted in England since the 1940's on Lady Eve Balfour's farm and known as the Haughley Experiment show that hens given organically grown grain began laying at an earlier age, 166 days versus 181 days. The hens produced more eggs over nine months, 192 per hen versus 150 per hen, with a better keeping quality of 27% vs. 60% spoilage after six months at room temperature. These studies have done more to persuade European farmers that organic farming can be competitive with chemical agriculture as any other single piece of research. Today, Dole, Gallo and Paramount, three of California's largest fruit and vegetable growers and large chemical users, are devoting large and increasing acreages to fertilization with manure-based compost.

In Colorado's San Luis Valley, one of the highest vegetable growing areas in the U.S., a thousand-acre vegetable grower is trucking chicken manure 225 miles from Albuquerque, NM to serve as the base for his chemical-free compost. The farm produces carrots, broccoli, turnips, beets and other vegetables with 85% going at premium prices in California and New York.

REDUCED OR ELIMINATED PESTICIDE USAGE

The composting process stops flies from reproducing, since they need moisture, heat and protein to survive. It takes about 10 days for a fly to develop from an egg to an adult; the speedy aerobic process disrupts the cycle and fly populations disappear.

The sterilizing heat of up to 160 degrees F. kills weed seeds in the feed and beddings as well as any disease organisms which would require corrective actions. Recently a Nebraska farmer, who had land disposed manures for years, justified the purchase of composting machinery on the yearly costs associated with herbicides to eradicate weeds incoming in the hay and grains. The State of Maine and Province of Prince Edward Island banned diseased seed potatoes from landfilling or ocean dumping, and composting was the only acceptable practice. After composting, the potato-based compost was sold back to the potato farmers certified-safe for use on their farms.

TECHNIQUES OF COMPOSTING

The transformation of organic waste streams can be accomplished in one of two manners: aerobic or anaerobic. The end products from anaerobic decomposition can result in serious nuisance conditions, especially organic fatty acids, aldehydes, alcohols, hydrogen sulfide, etc.

Aerobic decomposition by micro-organisms leads to the formation of oxidized end products such as carbon dioxide, water, sulfates, etc. Generally these compounds are considered to be stable and relatively non-offensive. Although no biological process is odor-free, the aerobic composting process when properly managed will have a musky, sweetish odor which is not offensive to the operator or outsiders.

Open windrow composting is the most prevalent technology used on the farm level up to and including large-scale programs on a corporate, municipal and even a county and regional basis. The open windrow process is being used in both wet and dry climates, at mountain altitudes or at sea level with year around success regardless of the temperature.

The primary factors affecting composting rates are those that influence biological activities. The key elements are the moisture content of the stream, the carbon to nitrogen ratio also referred to as the browns and greens, and the aeration of the mass of the matter in the windrow.

Moisture

Moisture contents plays a very important role, and a starting level of 60-70% moisture is necessary for microbial activity. Large amounts of heat are generated during decomposition, and unless sufficient water is available, the compost windrow will tend to dry out, dropping activity to almost zero. Higher water content will result in lower temperatures, and the material will be hosting the undesirable and potentially odorous anaerobic micro-organisms.

Aeration

Some type of aeration must be included in the handling of the material. Some is being done with forced air through the matter, some is being done with loaders, and we have seen windrows turned by pitchforks in the Third World countries or in the backyard heaps. The most desirable means, as well as the most economical and efficient, is a compost turner which is powered by an existing farm tractor or a wheel loader with a turner in a price range of from $15,000 to $100,000. The turner continually reduces particle size and breaks up large items as it makes passes through the windrow when required. The turner allows the operator to control the development of odors, provide thorough mixing for uniform high temperature destruction of weed seeds and pathogens and produce a uniform, high-quality mature compost equal to any produced in multi-million dollar installations.

Carbon-Nitrogen Ratio

Micro-organisms which decompose organic residues require nitrogen for their growth and activities. The amount of nitrogen required per unit of organic matter varies with the type of organisms involved in the process, and all are soil borne and only in remote situations require augmentation. Molds, which are very active during composting, require one part of nitrogen for every 30 parts of carbon. It is generally accepted that the carbon/nitrogen ratio of the organic mix will largely determine the speed of decomposition. A portion of the carbon is used to build microbial cells, while the remainder provides energy and is converted to carbon dioxide which is liberated.

During composting, nitrogen is immobilized and stored in the bodies of the micro-organisms with very little nitrogen liberated. The overall effect is that the C/N ratio is decreased greatly during the composting process.

COMPOST: A NATIONAL ASSET

Compost is produced by biologically reducing and stabilizing organic matter under controlled conditions into a range of products that are rich in humus, providing organic tilth and fertility to the growing plant.

The nutrients in the compost normally include nitrogen, potassium, phosphorus, sulfur, calcium, magnesium, boron, zinc, manganese, copper, iron and one barely recognized nutrient, humic acid, which can account for one-fourth of the compost's nutrient value.

Some Benefits of Compost Application

Improvement of soil structure. . . release of natural nutrients in the soil to the plant. . . increased movement, availability and retention of moisture up to two-thirds. . . promotion of greater bacterial action in the soil. . . helps rid the soil of excessive salt build-up. . . detoxifies soils that have been subject to heavy chemical applications . . . allows for increased root development to improve water and nutrient uptake. . . aids in maintaining proper soil pH. . . encourages the return of earthworms and micro-life. . . mature compost aids in speedier and higher seed germination. . . improves cation exchange capacity. . . acts as a root stimulant for bare root stock. . . facilitates safe, natural and non-toxic microbial action which is non-polluting and sustainable for years to come. . . increases yields after improving soil from chemical dependency. . . less expensive than escalating agrochemicals. . . helps drain boggy soils and hold water in sandy conditions, and. . . allows farmers and gardeners to provide greater health assurances to family and friends by eliminating chemical fertilizers and pesticides.

Values of Compost Products Today

The market for compost products of all types is increasing at the rate of 5% per year, and many of the large chemical fertilizer companies are either entering the marketplace or are conducting research on time-release, biologically friendly microbial fertilizers and friendly fluids for pest management.

We have surveyed the compost market from coast to coast, and we have been instrumental in a campaign to make environmental groups, Ducks Unlimited, State governments and regulatory personnel aware that peat from endangered wetlands is the largest dollar volume soil amendment sold across the U.S. Imported Canadian peat, a premium product with no nutrient values, sells at retail for up to $650 per ton.

We have recently informed state purchasing agencies that the mulch used for hydroseeding along highways is made from virgin timber, and it sells in the range of $250 to $350 per ton. Compost, on the other hand, has natural fertility and has proven to yield germination rates in excess of 90%, and it is available for less money with its contents made from potentially polluting manures, yard trimmings, brush, sod and old pallets destined for the landfills. One hydro-mix has cedar shake shingles which were recycled after hail damage into a compost made with turkey manure.

Just so you can realize the market prices for compost, here are some of the retail prices in 36 to 40 pound bags. Poultry compost with a variety of organic additions like leaves, waste newspaper, phone books, etc. is selling between $190 to $325 per ton. A grass and leaf product, called Second Cycle, is selling at $195 per ton, and these organic materials formerly were taking up 20% of the space in landfills and requiring a daily cover of six inches of clean soil. We can show you three quart, two pound bags of composted leaf mold fetching $4,300 per ton on most grocery store shelves.

Cleaner Production Makes Money

The poultry industry, with its rapid growth and increased consumer consumption, has the opportunity to lead the animal production industry in adopting environmentally sensitive and safe manure and waste management practices. Hopefully compost program implementation is being done or is in your plans for the future.

We're seeing threats of restrictions in production numbers in other animal breeds, and most recently the State of Texas and Washington State have told producers to clean up the situation or face a 25% reduction in dairy herd sizes. Feedlots in Nebraska, which all would drain surface or groundwater-wise to the Platte River, are seeing that composting is their only alternative to manage their flow of manure and stay "clean" in the eyes of the public and consumer.

REFERENCES

U.S. General Accounting Office, 1992. Food and Agriculture Issues. GAO/OCG-93-15TR.

Dean, Donna. The Effect of Farm Liquid Waste Application on Receiving Water Quality. RAC Project No. 512 G. Ausable Bayfield Conservation Authority. Exeter, ON.

Megalli, Nabil, 1992. Hunger Versus the Environment: A Recipe for Global Suicide. Our Planet: Vol. 4, Number 6. United Nations Environment Programme.

A GROWER'S PROSPECTIVE ON MANURE HANDLING AND DEAD BIRD COMPOSTING

Dennis Maze
Maze Poultry Farm
616 Stevenson Drive
Horton, AL

I have been a poultry producer for eighteen years growing 200,000 four pound birds for Hudson Foods near Albertville, Alabama. At present I am growing 150,000 five and one-half pound birds. Because of the shift in market demand the type of bird I have grown has changed slightly.

My farm is operated by myself, my wife, and my father. This farm has been in our family for fifty eight years and it is the way of rural life that we have chosen. We enjoy farming; however, it has been a challenge from time to time. Five years ago I was facing a serious problem with my poultry operation. I was told that I must come up with another method of dead bird disposal. This is when I made the decision to put in a composter. I built the second composter in Alabama. The composter is ten primary bins and one secondary bin. It was built from used material and it has served me well. Auburn University Agricultural Engineering Department and Poultry Science Department were my main supporters in this effort. Without them and the assistance of my county agent I don't know if I could have made the transition to a environmentally safe manner of dead bird disposal.

Composting has worked very well for me, it takes me about fifteen minutes a day to dispose of my dead birds and get them covered. From time to time I have to clean the composter out. This material is of high value and I use it on my garden and on my pasture land.

Wanting to be environmentally conscious and safe and being located very close to one of the major waterways in Alabama, I made the decision two years ago to install an on farm litter storage building. This building is 40 X 120 feet long and will store up to 800 tons of broiler litter. At the time of constructing the building it was my decision that I would use this structure to store material as it came out of the chicken houses and then use it later for land application.

Little did I know that I was about to embark on a completely new enterprise in my area of the state. The previous summer had been very hard on production of hay and we had little to feed our cattle as we went into the winter months. Livestock producers for as far as a hundred miles around were looking for high protein economical sources of feed for their cattle. As you know broiler litter has long been known as a excellent feedstuff for animals.

With both the building and some help from my county agent I have been able to start a custom feed mixing and selling business. During the first winter of this operation of the litter storage facility I was able to sell over 1,000 tons of broiler litter mixed with corn as a ration for cattle. This litter would have only been worth $5.00 a ton to me as sell as a fertilizer, but because of the ability to store and mix a little corn with the material I was able to charge as high as $20 per ton.

I don't know what the future might hold for me with respect to selling broiler litter as a possible feedstuff to my neighbors, but my experiences with the dry stack barn and manure has been excellent.

The dry stack facility offers a method for moving material out of the chicken houses in an orderly way during a time of year when crops cannot utilize the nutrients or the weather might be bad. In the long run I think most broiler farms in my part of Alabama will ultimately end up with some type of manure storage.

Thank you for the opportunity to come and share a little bit about my farm and operation with you.

NUISANCE COMPLAINT LEGISLATION

Michael T. Olexa
Professor
Food and Resource Economics Department
University of Florida
Gainesville, Florida 32611

Farmers and those who serve agriculture in both private business and public positions live and work in a progressively more complex environment of laws and regulations which have the force of law. Education in the law is becoming as important to successful management of agricultural enterprises as education in production technology, economics, and business methods. In recent years a complex body of federal and state laws and administrative regulations which relate to the quality of the environment has developed. These laws and regulations deal with such topics as point and non-point sources of water pollution, air pollution, use of pesticides, disposal of wastes, and many other situations that vitally affect those in agriculture. Knowledge of specific areas of law, such as environmental law and common law liability, is becoming as critical for the operation of a farm as knowledge of traffic law is for the operation of an automobile. This is especially true for farmers and ranchers with operations which are located in areas subject to increased population growth. It is in such areas that the issues of nuisance and right-to-farm legislation is of critical importance. This paper addresses the topic of nuisance law and its relationship to right-to-farm legislation. It does so by first discussing common law nuisance, then right-to-farm legislation, and finally the relief to a nuisance complaint.

The common law of torts imposes standards of behavior designed to deter wrongful, negligent, or unreasonably dangerous conduct and provides compensation for victims of such conduct. These standards apply society-wide. A tort is an act or omission that is deemed blameworthy, because the act or omission is either careless, shortsighted, unreasonably dangerous, or against a law or public policy. Unlike statutes and regulations, which often provide specific, technical guidelines on how specific agricultural practices should be carried out, the common law is much broader, addressing the reasonableness of all aspects of agricultural husbandry practices.

THE LEGAL PROCESS

A person injured in some way by the acts or omissions of another must file a lawsuit in order to be awarded compensation by a court. The person filing a lawsuit is called the plaintiff. The plaintiff(s) must do several things before a court will consider the lawsuit. First, they must allege that the person being sued (the defendant) harmed them in some manner. The lawsuit must also state a principle of law and allege that the defendant violated that principle. The principle may be one or more of the common law theories of liability, such as nuisance, or it may be a statute which prohibited or limited the actions taken by the defendant. The lawsuit must also allege facts which, if proven, would conclusively demonstrate that the defendant acted wrongfully or unlawfully, and that the plaintiff(s) suffered harm as a result. The plaintiffs will win if they can convince the judge or jury of the truth of these essential facts and if the defendant has no defense to these allegations. In civil cases the standard of proof will be whether the facts were proven by a preponderance of the evidence presented in court.

NUISANCE

Nuisance has traditionally been the most widely used theory in environmental pollution actions. Nuisances are categorized as either public or private, depending on whether the nuisance affects the rights of the public or the rights of an individual. The practical difference between public and private nuisances is that a public nuisance lawsuit can be brought by a public official on behalf of the public-at-large and that certain defenses, such as delay on the part of the plaintiff in bringing the action, are not available to the defendant. In some states certain types of public nuisances have been elevated to the level of criminal acts.

An example of a public nuisance involving animal wastes would be where wastewater runoff or flies interfered with the public's right to safe drinking water. A public official or individuals joined in a class action could obtain an injunction against the activity creating the public nuisance. An adjacent landowner may recover money damages from the defendant through a private nuisance action if, in addition to the interference with his right to safe drinking water, the landowner suffered the loss of livestock from the defendant's action.

Elements of a Nuisance Action

A private nuisance is a substantial interference with another's use and enjoyment of land. Unlike the trespass action, a physical invasion is not required. A substantial interference with the possessor's enjoyment of land, such as exposing that landowner to undue noise or unsightly appearance can constitute a nuisance. To constitute a private nuisance the interference must be wrongful. Interference may be wrongful in two ways. First, it may be intentional and unreasonable. The unreasonable element, absent from the stricter trespass action, allows the court to balance the social value of the offending activity against the plaintiff's injury. The second way interference may be wrongful is when it results from negligence, recklessness, or abnormally dangerous activities. The requirement that the nuisance must be wrongful is not strictly followed by many states. Courts will often find a nuisance from the mere fact that damage occurred.

A possessor of land who has suffered a substantial interference with the use and enjoyment of the land may obtain both monetary damages and an injunction against the defendant. In determining the remedy the court may consider both the value of the nuisance-causing activity to society and the gravity of the interests which have been invaded. Because this balancing test allows a court to consider the value and reasonableness of the defendant's activity, a plaintiff will normally prefer to bring a trespass action. Nuisance actions are usually brought in cases where a trespassory entry cannot be established.

For example, if improper waste disposal results in odors being carried onto adjacent property, the possessor could sue in trespass charging that the odors, which consist of molecules of the odor-producing substance, constitute a physical entry. If there is any doubt that the court will consider the odor a physical entry, the plaintiff will sue for a private nuisance, charging that the odors constitute a substantial interference with the plaintiff's right to use and enjoyment of the land. In a nuisance case the court will weigh the reasonableness of the defendant's activities. This rule will differ if the court determines that the defendant is engaged in an abnormally dangerous activity or the condition causing the nuisance is abnormally dangerous. In these cases, even if the defendant is acting reasonably, the danger of the activity or condition will be factored against him, sometimes overwhelmingly.

RIGHT TO FARM LAWS

In nearly every state limited protection from nuisance actions is given to farmers by state "right-to-farm" statutes. The general effect of these statutes is to allow farmers to assert as a defense to a nuisance action that the farm was in operation and the conditions complained about were in existence prior to the plaintiff's arrival. This defense, however, is limited. Most right-to-farm statutes do not affect the enforceability of federal or state anti-pollution laws or they are conditional on compliance with those laws. In those states where the defense is conditional on compliance with anti-pollution laws, the existence of a law forbidding air or water pollution will prevent the use of the defense in those cases where the nuisance consists of air or water pollution.

Furthermore, the defense is limited to nuisance actions and has no impact on other causes of action such as trespass or negligence. It is important to recognize that the statutes are intended primarily as a defense to complaints about odor, noise, and other common annoyances resulting from agricultural activities. The defense usually does not apply in cases where actual harm or pollution is caused by agricultural runoff.

INJUNCTIONS AND OTHER FORMS OF EQUITABLE RELIEF

Equitable relief is a remedy imposed by a court to compensate a plaintiff when money damages are inappropriate or insufficient. Usually equitable relief consists of one of two things. The first is an injunction, which is an order to the defendant to stop an activity. The second is an order to undertake an activity to correct or compensate for a previous harm. Equitable relief is common in nuisance and trespass actions. Before a court will grant equitable relief, it must determine that money damages are inadequate or unavailable to compensate the plaintiff for the type of harm suffered. Situations where money damages may be inadequate include where the nuisance will cause irreparable harm if continued, or where there is reason to believe that the harm will continue or recur after the award of money damages, resulting in future lawsuits.

In order for a court to grant injunctive relief the plaintiff must show that the defendant's activity is unreasonable at the time and place that the injunction is sought. In making this determination a court will balance the hardship that granting the injunction would have on the defendant, along with broader societal issues such as the value of the activity to the community or the harm posed by the activity to the community. For example, an ongoing agricultural operation that pollutes groundwater with poultry wastes might be shut down by an injunction if a court finds that the harm it causes outweighs any potential hardships on the defendant/owner.

Factors that could be considered in weighing the hardships on the defendant include whether the land has value for other uses and the extent of the defendant's investment. A court, however, will not balance the hardships if it determines that the defendant's actions were willful or against an assertion of right by the plaintiff.

CONCLUSION

Knowledge of nuisance law is vital for farmers and ranchers, especially in rapidly developing areas with expanding populations. In these situations farms and ranches face the threat of lawsuits, substantial settlements, including monetary payments, temporary shutdowns, and even permanent closure as common law nuisances. Right-to-farm laws are a powerful defense to nuisance claims for odor, noise, and other common agricultural annoyances. They protect normal farming and ranching operations in nearly every state, but they do not usually protect farmers and ranchers from charges of air or water pollution. Knowing of the potential for nuisance actions, and the available defenses, is the best preparation for farmers and ranchers.

The author is indebted to Rebecca L. Trudequ, Esq. for her review and critique of the paper.

INDUSTRY PERSPECTIVE ON NUISANCE COMPLAINTS

David E. Staples
President
Creekwood Farms, Inc.
N5505 Crossman Road
Lake Mills, WI 53551

Poultry manure management is a major concern of our industry. Not only is poultry manure a highly visible end-product of poultry operations; it is also quickly detected and rejected by anyone with a "nose" for what's going on in the world. It is human nature to exercise one's freedom of speech in regard to such a pungent topic; hence, today's producers receive feedback in the form of nuisance complaints. To address this topic and the handling of such complaints, I would like to give you a feel for how these complaints surfaced in regard to my own poultry operations.

BACKGROUND

Creekwood Farms, Inc. is a privately-held corporation. The company from which the corporation was formed is about 50 years old. It began strictly as an egg packing and distribution operation. In 1966, the first layer barn housing 30,000 hens was built. Two more 30,000 bird units were added in 1967 and 1969, respectively. Creekwood continued to purchase additional eggs from packaging and distributing until it was able to expand in size. The additional layer units were added from 1976 to 1981. Currently, it has a layer capacity of 535,000 hens. During the same five-year period from 1976-1981, two pullet grower facilities were added as well as a feed mill and a new packing plant.

Creekwood is located off Interstate Highway 94 in southeastern Wisconsin. Geographically, it is located 60 miles west of Milwaukee, 35 miles east of Madison, and 125 miles northwest of Chicago, Illinois. The farm is two miles from the small rural community of Lake Mills (pop. 4,500), which is situated on Rock Lake. The lake and community attract many visitors and temporary residents from the

Chicago area. Many have summer cottages and some even commute on weekends as well.

In its setting, Creekwood is surrounded by dairy farms and has only one neighbor within a 3/4 mile radius who is not associated with the company. Wisconsin is known for its hay crops and, in recent years, it has become more and more a significant corn and soybean producer. The farming in the Creekwood area is mainly corn with some beans, hay and wheat. In short, ours is a very rural area of small dairy farms.

COMPLAINTS

In such a situation, you would not expect to receive complaints, especially from other agricultural operations, unless the operation was poorly managed and polluted the environment, OR the facility was not typical of the other operations in the area.

We have been very diligent in keeping our farming operation clean, organized and operating efficiently. We have spent many dollars for landscaping, painting, tree trimming, etc. These have all helped build the public image of Creekwood Farms within the area, but it still has not be enough. Our complaints came as a result of some individual jealousy over our growth and success.

Almost all of the farms in our area are small farms; i.e., 50-85 cow dairy herds each farm having 100-300 acres of land. Because we have been labeled a "large-scale farm" according to one local farmer's opinion, this makes our large corporation out to take advantage of the little guy. Because this opinion was held and voiced by one particular neighboring farmer, it became an areas which we needed to recognize and address.

Along with this criticism, another area that caused us difficulty was our purchase of farm land as diary farmers sold their properties. We wanted to obtain all of the adjoining land around our farm if it became available, and when we purchased one farm in particular, the dairy farmer adjacent was very distraught that we were the buyer instead of him. As a result, he began a campaign to involve another neighbor who is a lawyer to file suit against us for contamination of underground was as well as surface water. All of this occurred in the spring of 1986 as we were seeking to increase our bird numbers under a Jefferson County Conditional Use Permit which would allow us to expand our operation from a 665,000 bird capacity to 1,475,000 layers and pullets.

On September 24, 1987, the local newspaper, the Lake Mills Leader, published a front page article outlining the issues. I quote from that article:

> A controversial decision will soon be made by the Jefferson County Planning and Zoning Committee that will impact on future growth of a Lake Mills corporation.
>
> That issue is county approval of a conditional use permit for Creekwood Farms, Inc. of Lake Mills to produce more eggs by adding about 845,000 more chickens to its existing layer farms, located south of the city. That would bring its total to almost 1.5 million birds.
>
> The problem is not with the chickens themselves. It's the additional tons of manure the new birds will produce and what can and should be done with the stuff. And that's where the story becomes complicated, laden with emotions, expert opinions and business decisions.
>
> On one side is Creekwood Farms, a locally owned and operated egg producing farm that employs 60 people and has an estimated annual payroll of over a million dollars.
>
> Creekwood Farms also buys several hundred tons of feed from local farmers. And, when you take into account the several thousand dollars Creekwood Farms pays annually in state and local taxes, you can grasp the firm's contribution to the local economy. Those are big numbers. An expansion would increase these numbers and many people's economic well-being.
>
> On the other side are concerns you can't easily put a price or a number on. Ground water that is safe to drink, air fit to breathe and a quality of life attractive to residents and tourists are issues opponents to the expansion cite.
>
> ...Harold Stilling, Jr., a neighbor of Creekwood Farms, questioned Creekwood's ability to safely dispose of the additional manure. Stilling said Creekwood twice was unable to meet county winter manure hauling and spreading regulations with their existing chicken population.
>
> "It's too much manure for the type of land that's out there," Stilling said. "Look at their six

years of manure spreading data on 600,000 birds. It doesn't look good."

Cottage owner James Clifford was concerned with monitoring Creekwood's manure disposal. "Who will watch how much and where manure is spread," Clifford wondered. "I am asking the zoning board to think about this when considering their permit."

A London Road resident said the nitrite level of contamination has increased in her well over recent years. Stevenson of the DNR said that if manure was spread in the proper manner, "it should not get into wells."

Shorewood Hills resident William Scheisser said Creekwood's increased chickens are "big time expansion. Hard questions must be asked. If they're not answered the permit can't be granted." In a letter to the committee, Schmeisser sought county actions to verify ground water testing for manure pollutants and Creekwood's overall compliance with permit conditional use requirements.

One neighbor was opposed to the expansion because he feels "offensive airborne pollution will increase."

Another was concerned with runoff creating weed problems in nearby creeks, marshlands and lakes. Stevenson responded that weed problems "were not necessarily due to Creekwood Farms' runoff. There are many, many other possible sources."

Margaret Krueger presented the committee with a petition signed by 35 persons who felt the public was not adequately notified by the county of this hearing. Krueger also stated concern for odor problems, and well and lake contamination if the expansion was approved.

Lloyd Hornbostel of Elm Point Road said quality of life is a major consideration the committee must examine.

"If the expansion is granted and there is a problem, we the people will pay for it," Hornbostel said. "The DNR permit is not a guarantee. It's a best effort's guess that the thing might work. It should be delayed until the questions asked tonight are answered."

Peter Stilling of London Road said the expansion could jeopardize the "natural gifts" of Rock Lake and local tourism that all Jefferson County residents benefit from.

"As you weigh the balance between good and bad on this, the losses outweigh the good," Stilling said, "And that's why we're opposed." (Kobinsky, 1987)

As a result of these complaints, it took us six and a half years to obtain our permit. The permit was finally granted on September 8, 1992. It goes without saying that this permit did not come easily, even then. Jefferson County in Wisconsin has been on the cutting edge in environmental protection and county authorities are very diligent in seeing that all businesses operate within the guidelines of the permits issued.

RESOLUTION

To resolve the permit process, we utilized the following agencies with whom we had been working closely for many years:

Jefferson County Zoning Board
Wisconsin Department of Agriculture Office of Trade and Consumer Protection
USDA Soil Conservation Service
Wisconsin Department of Natural Resources

The results of working with these agencies was to develop a Creekwood Farm, Inc. Manure Management Plan. I quote from that plan:

As part of the criteria established by Jefferson County and the discharge permit requirements by the DNR, Creekwood Farms, Inc. has prepared a manure management plan. This plan was developed in consultation with the USDA Soil Conservation Service, the Wisconsin Department of Agriculture Trade and Consumer Protection and Wisconsin DNR.

The standards and specifications which were used to develop this plan can be found in SCS Standard No. 633. This standard is a technical guideline used by SCS to establish acceptable application rates for spreading manure on cropland. This standard takes into consideration the following factors: manure production, nutrient content, and a variety of soil and water conservation factors. The standard has been adopted by both DATCP and DNR for use in their water quality improvement programs.

Our manure management practices were as follows:

> Creekwood Farms owns and operates the manure spreading equipment used to spread the manure.
>
> The manure is surface applied on acreage which has a variety of cover crops. The amount of manure applied per acre will be determined by dividing the nitrogen uptake of the crop for a given yield ton basis by the amount of available nitrogen per ton of manure. This will give the tons of manure/acre needed by the plant. The nitrogen uptake of the crop is to be determined by using current USDA/SCS standards. A record of total tons per field is maintained to check the tons per acre. This record shows total nitrogen needed for the crop and the total amounts applied and dates applied.
>
> Current soil testing procedures are based on a sample collection system. Lab personnel collect composite samples for the fields. The soil test locations are preselected. The composite samples are sent to a certified soil testing lab for analysis. The testing lab provides a recommended nitrogen application rate based on yield goals established for each specific field. Field personnel complete a daily log sheet during the period of daily application. (Creekwood Farms, Inc., 1986)

CONCLUSION

I have included this reference to a portion of our Manure Management Plan to emphasize a particular point. If we as an agricultural industry are going to be successful with our farming operations, we must view our manure as a nutrient to plants and develop ways to properly utilize all we produce. The nature of manure is very compatible with our environment, probably moreso than chemical fertilizers, the major objection having been its odor. The general public will not tolerate manure odor but has very little objection to the odors of chemical fertilizers. So often in the past, manure has been treated as a waste product instead of a resource. Through the development of our Manure Management Plan, and working with manure as a resource rather than a waste product, we have been able to develop markets for the manure that provide us with revenue and a product that is environmentally beneficial and very acceptable odor-wise. As a side benefit to us, the complaints have also creased.

In summary, it is my opinion that we will all continue to find it more and more difficult to operate our agricultural enterprises. We will continue to have more and more regulations to deal with and it will become a necessity to evaluation how we are going to deal with manure.

After six and a half years of hearings, testimonies, courtrooms, lawyer's questions, calls, complaints, etc., the real question that had to be answered was, "What are you going to do with the tons of manure that will be produced?" That same question might well be asked of any large producer. You can be the best egg marketer in the world, you can be the most efficient producer, you can attract the highest-ranking politician to be on your side, you can have tons and tons of documentations of what you are doing. But when all is said and done, it's not going to help unless you have dealt properly and responsibly with all the manure you are producing.

Manure can be a liability or an asset and we will be required to not only make it as asset monetarily but also environmentally. We must change our thinking and forget the traditions of the past which treated manure primarily as a waste product. We must be creative in developing ways to utilize the manure to be mutually beneficial to our own companies' interests as well as to the industry and the environment.

No one will be immune from dealing with manure on an environmentally responsible basis. The challenge I accept and extend to you is to help each other and help agriculture by being responsible environmental caretakers.

REFERENCES

Creekwood Farms, Inc., 1986. Manure Management Plan. p. 3.

Kobinsky, Tom, 1987. "Creekwood Expansion Opponents Voice Their Concerns." Lake Mills Leader, p. 1.

AN ENVIRONMENTAL GROUP'S PERSPECTIVE OF WHAT NEEDS TO BE DONE

Karen Firehock
Program Director
Save Our Streams
Isaac Walton League of America
Alington, VA

Save Our Streams (SOS) is the grassroots river conservation program of the Izaak Walton League of America. SOS was founded in 1969 in the state of Maryland. In the early 1970's the program was expanded nationwide through the SOS Water Wagon, a large mobile environmental learning center, housed in a Winnebego, that traveled to every state in the U.S. and educated as many as 2,000 people a day. Today the SOS program tracks projects in very state through the SOS database called Monitors and SOS staff provide technical assistance to groups through workshops, handbooks, video, slide shows and the tool-free assistance hotline 1(800)Bug-IWLA.

SOS works with many diverse groups including the agricultural and livestock communities. SOS has a Memorandum of Understanding with the U.S. Soil Conservation Service to work together to involve the agricultural community in water monitoring and stream restoration projects. SOS teaches livestock managers to assess the quality of their local streams through simple hands-on techniques that require minimal training and expense. As the number of poultry farms and animal units continue to increase, many groups are increasingly concerned about the potential for offsite impacts to nearby surface and ground waters from nutrient overload from manure runoff and the potential for pathogens to reach and contaminate surface waters.

Poultry operations may want to consider learning SOS monitoring techniques as a way to gauge if their operations are adversely impacting surface waters on site or streams nearby their operations. By learning to monitor their streams, poultry producers can achieve several important objectives. They can:

1. Demonstrate themselves to be good corporate stewards;
2. Determine if their operations are impacting surface waters;
3. Develop solutions to correct problems before they become serious, and;
4. Keep a record of the water quality at their site so that if problems do occur it will be easier to track the source.

REMOVAL OF NITROGEN AND PHOSPHORUS IN POULTRY PROCESSING WASTEWATERS

John A. Pierson
Research Engineer

Russell Ray
Research Scientist

Robert Wallace
Chemical Technician
Georgia Institute of Technology
Atlanta, GA 30332-0800

Georgia's growing economy has fueled a rapid population increase along with industrial growth. As a result, consumer and industrial demands upon Georgia's water resources have risen while causing increased wastewater discharge volumes. The impact of these increases has had the greatest effect upon industrial users. Federal regulations have required state agencies to tighten restrictions to maintain, and in many instances, regain higher water quality for continued support of the state's growth and to preserve the national environment. While both municipal facilities accepting industrial wastewater and direct discharges are affected by tougher standards, industrial facilities feel the brunt of these actions due to the shear volumes discharged.

Initially, only BOD_5 removals were required, and primary treatment alone removed sufficient suspended solids and organic matter to provide acceptable effluents. Continued receiving stream water quality degradation, however, has resulted in more prevalent nitrogen and phosphorus discharge limits. Processes which effectively meet these discharge permit limits typically demand higher rate systems and BOD_5 or COD reductions beyond permit requirements to achieve nutrient removals, a cost processors prefer not to incur. Even those processors currently well within limits could encounter surcharges if:

- limits are reduced;
- processing capacity increases beyond treatment capacity;

- facility pre-treatment process changes or an upset occurs.

Any of these conditions could cause surcharges and combinations of these factors could prove particularly difficult to offset. Careful analysis of wastewater nutrient characteristics, permitted discharge limits, and alternatives which provide flexibility, however, will allow poultry processing facilities to operate and grow in a profitable manner.

Why Are Nutrients a Problem

Although biological growth requires nitrogen and phosphorus as macronutrients, concentrations above naturally occurring levels provoke imbalances in receiving streams. Excessive macronutrients initiate rapid growth of aquatic plants, reducing dissolved oxygen levels. These additional aquatic plants block out sunlight to other plants and destroy the receiving waters' normal ecosystem. Eventually, these plants die, resulting in organic matter (carbon) and nutrients that fuel further bacterial growth and thus reductions of dissolved oxygen levels. Also, ammonia is toxic to aquatic organisms above certain levels.

After carbon, the next most abundant element in the cell is nitrogen, with a typical bacterial cell consisting of 12-15 percent nitrogen by dry weight. Nitrogen is present in nature in both organic and inorganic forms. The majority of available nitrogen in nature is in the inorganic form, either as ammonia (NH_3) or nitrate (NO_3). Organic nitrogen includes natural materials such as proteins and peptides, nuclei urea, and numerous synthetic organic materials. Analytically, organic nitrogen and ammonia are referred to as total Kjeldahl nitrogen (TKN). Most bacteria utilize ammonia as the sole nitrogen source and many also use nitrate. For nitrogen removal, carbonaceous oxygen demand is initially removed, followed by the conversion of nitrogenous material (ammonia) into the nitrate form (nitrification). Denitrification can also be utilized to convert nitrate into nitrogen gas. The various forms of nitrogen are illustrated by the "nitrogen cycle" in Figure 1.

Phosphorous is also a major micronutrient used by bacteria present in nature in organic and inorganic forms. Most microorganisms utilize inorganic phosphate (PO_5) for growth, but some bacteria breakdown the organic phosphates which make it more usable to other bacteria. Phosphorus occurs as organic phosphorus found in organic matter and cell protoplasm, as complex inorganic phosphate (polyphosphate) and as soluble inorganic orthophosphate (PO_5);

orthophosphate is the final breakdown product in the phosphorus cycle and the form most readily available for biological use or for precipitation by a metal salt.

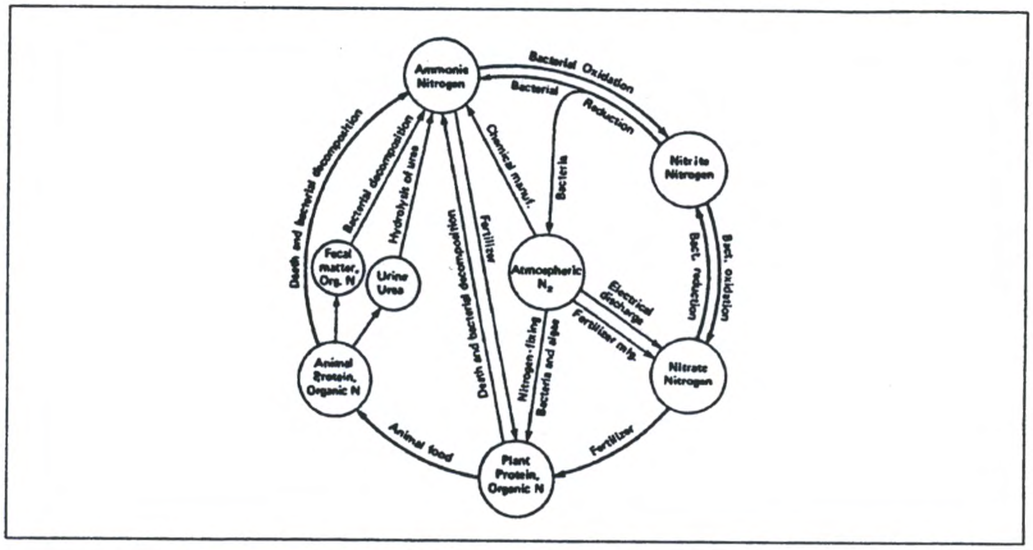


Figure 1. Nitrogen Cycle (from Wastewater Treatment Plant Design, WPCF MOP No. 8).

Phosphorus removal from wastewater involves the incorporation of phosphate into a particulate form (suspended solids) followed by the removal of the suspended solids. Typically, solids would be biological, incorporated in the microorganisms present in the waste stream, or chemical, as the sparingly soluble metal phosphate precipitates. For dissolved air flotation (DAF) units utilizing coagulants and/or polymers, removal of the suspended solids incorporates chemical pre-precipitation of phosphorus before DAF discharge (Sedlak, 1992).

SURCHARGES AND PENALTIES

In order to assess the food processing industry's contribution of nutrients to municipal wastewater streams and the economic impact of reducing nutrients discharged, a background review and economic analysis was conducted. The economic impact of discharging nutrients at various locations in the state was then determined to evaluate the feasibility of future treatment processes.

Municipal Survey

A background review was completed to establish the range of possible costs that could be incurred based upon the location of the facility and to determine whether nutrient removal currently warranted concern. Initially, the USEPA was contacted. An official stated that nutrient removal limits were very site specific and dictated by local municipalities. These criteria were based upon permits regulating discharges to the receiving streams or estuaries. There were currently no USEPA dictated standards or plans to develop any.

Various municipality officials were then contacted throughout the state and asked to detail applicable phosphorus and nitrogen surcharge limits for direct or industrial pretreatment discharge. All officials agreed surcharges were designed to discourage discharge of a particular pollutant, and usually a limit was set above which discharge was prohibited and fines were issued. In situations where limits were lowered without implementing a surcharge system, an equipment upgrade was usually necessary to continue discharging. Each individual facility then, however, made relevant equipment decisions based on its particular situation. Table 1 details results of the telephone survey conducted.

Table 1. Applicable Surcharge Limits and Rates

Location	Phosphorus limit (TP) (mg/l)	Nitrogen limit (mg/l)	Phosphorus surcharge rates	Nitrogen surcharge rates
City of Atlanta	10-15 (proposed)	25 (as TKN)		\$0.50/lb
Gwinnett County	10	20 (as NH_3-N)	\$1.04/lb	\$0.70/lb
Fulton County	5-15	25-50 (as TKN) (pending)	\$2.00/lb	(pending)
City of Macon		30 (as NH_3-N)		\$0.87/lb for 20-24 mg/l \$1.74/lb for 25-30 mg/l \$1000 fine for >30 mg/l
City of Gainesville	10 (16 max)	40 (75 max) (as TKN)	\$0.014/mg/l/CCF for 10-15 \$0.028/mg/l/CCF for 15-20 \$0.056/mg/l/CCF for 20-25 \$0.112/mg/l/CCF for > 25 All per 748 gals	\$0.004/mg/l/CCF for 40-75 \$0.008/mg/l/CCF for 75-90 \$0.016/mg/l/CCF for 90-105 \$0.032/mg/l/CCF for > 105 All per 748 gals

The survey revealed a range of nutrient discharge limits with varying surcharge rates. The cities of Gainesville and Macon programs appeared to be the most progressive, with increasing surcharges for increased amounts of pollutants. For Gainesville, phosphorus was not as large a problem as nitrogen because the TP limits have been in effect at one level or another for 12 to 15 years. The metro Atlanta area, however, was beginning to feel the effects of neglecting phosphorus discharge limits, as evidenced by the stiffer surcharge rates set to quickly ensure compliance. While each municipality differed, the overall objective ensuring local Publically Owned Treatment Works (POTWs) could adequately treat both domestic and industrial discharges appeared to drive the surcharges set.

Estimated Charges from the Survey

Determining the overall economic impact of surcharge rates on poultry processing facilities throughout the state of Georgia was difficult because different facilities utilize distinctive primary and secondary treatment schemes. Additionally, not all facilities discharge effluents to municipalities. Finally, the surcharge limits and rates vary in different regions of the state.

To assess the impact of surcharge limits and rates within the state, a final plant discharge effluent was estimated, based upon results found in the literature. Because of the limited availability of phosphorus data, laboratory tests were conducted. Effluent characteristics were based upon a facility employing screening and dissolved air flotation (DAF) only before discharge. Table 2 depicts typical effluent levels.

Table 2. Typical Post DAF Effluent Levels, mg/L

Source	BOD_5	COD	TSS	FOG	TKN	Ammonia
Merka (1990)	350	440	---	---	---	---
Peace (1993)	450	---	250	75	100	59
Daly (1990)	175-400	---	75-200	5-20	---	40-60
This Study	---	498-668	53-140	---	---	22-25
GTRI (1994)	131-269	254-770	55-174	---	110-169	14-33

The plant discharge, at 1 MGD for 5 days a week or 20 million gallons per moth, was assumed to be initially treated with a DAR unit, utilizing metal salts and polymer. The range of phosphorus in the effluent of a poultry facility processing wastewater was considered to be 8.3 to 13.6 mg/l, averaging 11 mg/l, based upon laboratory testing. The effluent phosphorus levels after metal salts/polymer coagulation were determined to be typically around 3 mg/L. Nitrogen levels as ammonia (NH_3-N) and as total Kjeldahl nitrogen (TKN) were assumed to be 40 mg/L and 100 mg/L, respectively, based upon Table 2.

Table 3. Potential Surcharge Costs for a Typical Poultry Processor

Period	Atlanta	Gwinnett	Fulton	Macon	Gainesville	Athens
$/Day						
TP	PROPOSED	0.00	0.00	NL	0.00	NL
NH_3-N	NL	117	NL	399	NL	NL
TKN	313	NL	PROPOSED	NL	455	NL
$/Week						
TP	PROPOSED	0.00	0.00	NL	0.00	NL
NH_3-N	NL	584	NL	1,997	NL	NL
TKN	1,564	NL	PROPOSED	NL	2,273	NL
$/Month						
TP	PROPOSED	0.00	0.00	NL	0.00	NL
NH_3-N	NL	2,335	NL	7,987	NL	NL
TKN	6,255	NL	PROPOSED	NL	9,091	NL
$/Year						
TP	PROPOSED	0.00	0.00	NL	0.00	NL
NH_3-N	NL 75,060	28,022	NL	95,878	NL	NL
TKN		NL	PROPOSED	NL	134,759	NL

Based upon the average nutrient discharged levels stated above and the associated flow rate, this typical poultry processing plant could expect surcharge amounts as shown in Table 3 for the municipalities surveyed.

Presently, poultry facilities conducting wastewater pre-treatment typically remain below surcharge levels for nutrients. Nevertheless, processors discharging to municipal POTws often must monitor and report nitrogen discharged in the form of TKN or ammonia. Five of the six municipalities contacted have instituted a surcharge structure for industries that are municipal dischargers, and several limits were pending at the time of the survey. For our hypothetical plant, TKN limits had the largest impact. A facility in Atlanta would be charged $75,060 per year, and a facility in Gainesville would be charged $134,759 per year.

The nitrogen problem Gainesville has encountered resulted in a recent wastewater treatment plant upgrade. The upgrade allows nitrification and denitrification. Based upon current TKN effluents, one processor estimated a $40,000/year surcharge impact. While the city has not started billing for TKN surcharges yet in order to give facilities time to comply, as payments come due on the new construction, sources of revenue will certainly be implemented.

Future Economic Cost

Recently in Georgia, the focus on phosphorus, particularly along the Chattahoochee River (a critical supplier of water to the state) has increased. Because the minimum solubility of phosphorus is approximately 5.5 pH units (Sedlak, 1992), pending upon metal salt used in a DAF, acidulation will result in higher phosphate levels in effluents. Additionally, Merka (1990) reported from 1986 to 1989, the average rate of water and wastewater treatment charged by the ten municipalities that provide water to and/or receive wastewater from George poultry processors has increased from $1.65 per 1000 gallons to $2.35 per 1000 gallons, a 43 percent increase. More stringent wastewater quality discharge standards may cause rates to increase to $7.00-$8.00 per 1000 gallons by the turn of the century. To prevent this rapidly increasing cost from impacting the profitability, processors must become more efficient in water use, wastewater loading, and wastewater treatment.

TREATMENT METHODS

The treatment objective for removal of nitrogen and phosphorus in a poultry processing facility's wastewater ultimately defines the process utilized. Discharge limits and associated surcharge rates, effectiveness of potential options, capital and operating costs weigh heavily upon the final decision of whether to upgrade facilities. Many researchers have also pointed out, however, the importance of waste minimization and pollution prevention as a first step.

Water Minimization

Efforts have recently been made to encourage quantifying waste characteristics and sources before attempting to manage final plant effluent controls. Carawan (1989) highlighted the cost savings possible for various types of food processors through pollution reduction. Richardson (1990) emphasized the need to effectively manage and inform people regarding waste reduction to improve effluent quality. Additionally, Merka (1990) noted that by analyzing the sources of waste loadings with regards to permitted contaminants, processors could greatly improve effluent quality.

Processing Modifications

Once waste reduction audits have been completed and strategies implemented, the requirement for wastewater treatment will still exist; even with closed-loop systems, the contaminants removed must be disposed of, along with any dry-sweep materials. Additionally, because an optimized end-of-pipe treatment system coupled with minimized water usage provides added processing capacity, increases will eventually push the system to failure as screens and DAFs exceed capacity. At this point, capital costs of modifications will probably be off-set by production revenues, thus enhancing the value of process modifications.

Potential on-site nutrient removal alternatives may initially seem limited, but the preponderance of available proprietary systems vastly increases the apparent complexity of the final decision. Biological, physical/chemical and natural systems are three general categories of current state-of-the-art applications. The options reviewed were based upon a poultry processing facility which pretreats wastewater for discharge to a municipality. The effectiveness of the options evaluated for nutrient removal can possibly enhance performance for direct discharge facilities, but associated costs will probably be higher.

Biological

Biological alternatives for nutrient removal include technologies currently utilized by poultry processing facilities and also treatment systems new to even domestic wastewater treatment. Table 4 details a brief description of biological options available.

Aerated lagoons can be modified to improve overall performance, but nutrient removal is limited. While SBRs and fluidized beds provide both nitrogen and phosphorus removal, capital costs may be high to treat the entire waste stream. Additionally, fluidized bed technology is more susceptible to mechanical problems.

Anaerobic systems were not directly included in the overview, primarily because these systems produce ammonia from the biotransformation of proteins and other nitrogenous sources. It should be noted, however, an anaerobic step is necessary for biological removal of phosphorus.

Physical/Chemical

Although biological treatment is the most common nitrogen control strategy used, physical and chemical processes have been found to be technically and economically feasible under certain situations for nutrient removal (Sedlak, 1992). Chemical additions, as metal salts, used to precipitate solids typically also remove phosphorus while only removing particulate organic nitrogen present.

Table 4. Biological On-Site Nutrient Removal Process Options

	Aerated Lagoon	Sequenced Batch Reactor (SBR)	Biological or Trickling Filter	Fluidized Bed Systems
PROCESS DESCRIPTION	Medium-depth basin designed for continuous, biological treatment	Fill and draw aerated basin	Aerobic tower with attached growth	Aerobic biological treatment unit
EFFECTIVENESS				
Nitrify	Yes	Yes	Yes	Yes
Denitrity	No	Yes	Yes	Yes
Phosphorus	Yes	Yes	Limited	Yes
COSTS				
Capital	Low	High	High	High
Operating	Med	Low	Low	
ADVANTAGES	BOD removal Low costs	Flexible	Suited for strong wastes Little mechanical equipment	Increased loadings Suited for strong wastes Small area
DISADVANTAGES	Sludge Space Inflexible	Sludge	High headloss Best above 13^{o}C Fly/odor nuisance	

Recent interest in the treatment of struvite, and undesirable by-product of anaerobic digestion, has sparked interest in attempting to removing phosphorus and nitrogen simultaneously by chemical precipitation. Schulze-Rettner (1993) reported precipitation of ammonium with phosphate and magnesium to lower the nitrogen content of wastewater. Webb et al. (1993) reported field and laboratory data comparisons indicating the potential for precipitation as a method of nitrogen was removed and only initial studies were made. Also, the reliability of this method has yet to be proved, along with documentation of initial capital costs, operating costs and effectiveness. Table 5 summarizes key points inherent to common physical processes used by food processors.

Air stripping is best applied to wastewaters with high ammonia contents (Typically above 10 mg/L), but the initial capital costs and operating costs are high and ammonia stripping has no effect on organic nitrogen, phosphorus or carbonaceous BOD removal. This is especially important is the wastewater TKN is predominately organic nitrogen versus ammonia. Breakpoint chlorination is effective as a removal process for ammonia, but as the ammonia stripping, no organic nitrogen, phosphorus or carbonaceous BOD removals occur. Ion exchange is usually applied for ammonium removal, with only limited organic nitrogen, phosphorus and carbonaceous BOD removal; removals occur at the expense of ammonium removal as the bed becomes quickly fouled by these substances, requiring added operating costs to more frequently regenerate iron-exchange beds.

Table 5. Physical/Chemical Nutrient Removal Process Options

	Chemical Precipitation	Ammonia Stripping	Breakpoint Chlorination	Ion Exchange
PROCESS	Chemicals added to remove nutrients as Struvite	Packed tower, desorption process	Chlorine added to Oxidize NH_4 to N_2	Resin reduces NH_4 levels
EFFECTIVE				
Ammonia	Yes	Yes	Yes	Yes
Nitrates	No	No	No	No
Phosphorus	Yes	No	No	No
COSTS				
Capital	Low	High	Low	High
Operating	High	High	High	High
ADVANTAGE	Dual nutrient removal at once	Efficient NH_3-N removal, 20°C	Not effected by temperature	No temp. effects No emissions NH_3 made into fertilizer
DISADVANTAGE	Low strength waste Sludge dewatering Operator intense New technology High pH operation	Poor efficiency below 10°C Sludge Discharge NH_3N to atmosphere High pH operation	Operator intensive Effluent TDS increase Discharge to atmosphere	Possible scaling Must handle spent regenerant Influent must have low TSS

Natural Systems

Natural systems are becoming more popular due to the inherent simplicity of operations, the biological nature of the treatment process, enhancement to wildlife environs afforded and the potential of deriving a useful by-product.

While natural systems are most beneficial for nutrient removal and additional treatment of secondary effluents, aquatic plant basins and constructed wetlands can require large tracts, are subject to climatic conditions and require plant harvesting and subsequent plant disposal.

For nutrient removal applications, biological systems tend to be more economical and effective because these systems are capable of treating many other permitted compounds. Physical and chemical systems optimize results when dealing with one main compound of interest; more recent technologies look to improving phosphorus and ammonia removals, but organic nitrogen is not treated. Natural systems provide benefits similar to engineered biological systems, but its very nature predisposes it to inflexible operation and control. Table 8 depicts key considerations regarding natural systems.

Table 6. Natural System Nutrient Removal Process Options

	Aquatic Plants	Constructed Wetlands
PROCESS DESCRIPTION	Medium-depth basin designed for continuous treatment using aquatic organisms (flora and fauna)	Low-depth basin designed for continuous treatment using plants, invertebrates and fish and integrated polyculture foodchain systems
EFFECTIVENESS		
Nitrify	Yes	Yes
Denitrify	Yes	Yes
Phosphorus	Yes	Yes
COSTS		
Capital	High	High
Operating	Low	Low
ADVANTAGE	Enhances wildlife habitat BOD removal Low costs	Enhances wildlife habitat
DISADVANTAGE	Sludge removal Land intensive Harvesting/removal of plants	Sludge removal Land intensive Harvesting/removal of plants

CONCLUSIONS

Many poultry processing plants impacted by nutrient removal regulations discharge directly into municipal systems. This impact is felt because, unlike direct dischargers, these facilities generally do not have biological processes in place to provide the necessary secondary or advanced treatment needed for nutrient removals nor the land to install low-rate biological systems such as lagoons. Thus, wastewater discharges, particularly those that are relatively clear of suspended matter, yet rich in dissolved nutrients, could cost processors money.

The merits and drawbacks of biological, physical/chemical and natural systems must be considered in a general sense in addition to the role of each system at a poultry processing facility. Biological, physical/chemical and natural systems each offer viable alternatives for incorporating or enhancing nutrient removals. Although each type of system affords distinctive benefits and weaknesses, the desired level of treatment, influent concentrations and overall costs should be considered when evaluating an option.

To properly examine the impact of biological, physical/chemical or natural systems on existing facilities, processors must ensure current systems are operating optimally. Also, in-house improvements such as reconfiguration of existing treatment processes may increase facility optimization; improvements may be as simple as modifying collection of high strength wastes or adding baffling to lagoons for increased HRTs. Finally, evaluating the sources of greatest nutrient loadings to potentially identify sites for side-stream treatment. Once these considerations have been thoroughly reviewed, evaluating biological, physical/chemical or natural system alternatives within the context of facility needs will be clearer.

REFERENCES

Carawan, R. E., 1989. Observed impact of pretreatment regulations on food processors. Proceedings of the 1989 Food Industry Environmental Conference, Georgia Tech Research Institute, Georgia Institute of Technology, Atlanta, Georgia.

Daly, T., and A. C. Gray, 1990. Wastewater treatment for a poultry processing facility: a case study. Proceedings of the 1990 Food Industry Environmental Conference, Georgia Tech Research Institute, Georgia Institute of Technology, Atlanta, Georgia.

Merka, W. C., 1990. A characterization of wastewaters discharged by a modern broiler processing plant. Report to the Southeastern Poultry and Egg Association, Project No. 355.

Operation of municipal wastewater treatment plants. Manual of Practice 8, Water Pollution Control Federation, Alexandria, Virginia, 1990.

Peace, W. G., and K. Krupa, 1993. Poultry plant wastewater upgrade using fixed-film reactors: a case study. Proceedings of the 1990 Food Industry Environmental Conference, Georgia Tech Research Institute, Georgia Institute of Technology, Atlanta, Georgia.

Pierson, J. A., and R. W. Wallace, 1994. Pretreatment of poultry processing wastewaters utilizing sequencing batch reactors. Final Report for Agricultural Technology Research program Project N3200-460, June.

Richardson, S., 1990. Waste reduction in food processing: a people management issue. Proceedings of the 1990 Food Industry Environmental Conference. Georgia Tech Research Institute, Georgia Institute of Technology, Atlanta, Georgia.

Schultze-Rettmer, R., 1991. The simultaneous chemical precipitation of ammonium and phosphate in the form of magnesium-ammonium-phosphate. Water Science Technology, 23, p. 659.

Phosphorus and nitrogen removal from municipal wastewaters: principles and practice. 2nd Edition, R.I. Sedlak, ed., Lewis Publishers, New York, 1991.

Webb, K. M., 1992. Struvite ($MgNH_4PO_4 \cdot 6H_2O$) solubility and its application to a piggery effluent problem. Water Science Technology, 26, p. 2229

WASTE STREAM IDENTIFICATION

William C. Merka
Extension Poultry Scientist
The University of Georgia
Poultry Science Department
Four Towers Building
Athens, GA 30602-4356

Poultry is made up of five components, protein, fat, water, minerals in bones and residual feed in the intestinal tract. Three of these components, proteins, fat and intestinal tract residue, are of concern to wastewater treatment. Each of these components of concern have specific properties, both chemical and physical. These components are discharged to the waste stream by specific processes and by specific process order. An understanding of the properties of waste stream components and processes that add them to the waste stream can assist processors in designing systems that either excluded pollutants from the waste stream and/or remove them most efficiently.

Proteins

Two major protein components in the waste stream are blood and tissue particles. Blood enters the waste stream mainly at the killing operation. Efficient blood recovery is essential to reduce wastewater strength. Excessive blood discharged from the killing operation reduces blood yield to rendering and causes increased pretreatment and treatment costs. Blood has a BOD_5 of approximately 100,000 mg/L. Because of the high BOD concentration in blood, small amounts lost to the waste stream can significantly increase wastewater strength. One gallon of blood will increase the BOD of 1,000 gallons of wastewater by 100 mg/L. Blood is also difficult to flocculate from the waste stream. More chemical treatment is required which increases chemical costs.

Protein tissue particles is mainly produced by the evisceration operation. As the birds are eviscerated, giblets harvested and the birds chilled, small tissue particles are removed from the birds and offal and discharged to the waste stream. The larger tissue particles are removed by the primary and secondary screens. Protein tissue particles passing through the screens must be removed by flocculation prior to wastewater discharge to municipal sewers. Excessive particulate matter in the waste stream produces excessive DAF skimmings which can lower the quality of rendered products.

Fat

The evisceration process is the main source of fat in the waste stream. As viscera is drawn, giblets harvested and the birds are washed, fat debris is washed into the waste stream. Fortunately fat has a lower density than does water and floats rapidly to the surface. To take advantage of this property, the fat component should be gently treated to prevent emulsification. One processor installed a small fat separation unit (45 seconds detention time) to receive wastewater passing through the evisceration primary screens. The sweeps in this small separator removed a large amount of fat from the waste stream. Since this fat had been excluded from the flocculation process a greater volume of high quality fat was recovered for rendering. Exclusion of this fat from the DAF process reduced DAF chemical costs by 20 percent.

Intestinal Contents

Residual manure and feed particles can cause wastewater problems. Feed particles are more a physical problem than a wastewater problem. Feed particles settle rapidly and can build up in flumes and drains. Water is used to remove them. Since these particles settle rapidly, a well designed grit chamber will capture and remove feed particles.

Excessive intestinal contents can increase the ammonia concentration to increase. The data in Table 1 shows a six fold increase in the ammonia concentration when evisceration water was used to flush feathers. Manure being washed from the birds by the scalder was the ammonia source. Manure deposited at live haul and hanging can cause an increase in ammonia concentrations if it is washed into the waste stream.

Table 1. Characteristics of Wastewater Discharged by Three Processes of a Broiler Plant

	Percent of flow	TVS		FOG		NH_3	
		mg/L	%total	mg/L	%total	mg/L	%total
Evisceration	49	4088	69	1924	75	3	15
Feather flow	35	1833	22	617	17	19	68
Offal truck	3	5407	8	1468	5	36	9

Offal Truck

Although a small part of the operation, the drain from the offal truck can deliver an inordinate amount of organics to the waste stream. In one turkey plant studied, the offal truck contributed one-third of the plants BOD load although it contributed only three percent of the flow volume.

Excessive organics added by the offal truck can be caused by:

1. Primary screens that are too short and unflighted. These screens allow excessive water to flow into the offal augers and to be carried into the offal truck. This excessive water is discharged through the drain ports carrying excessive organics with it.

2. The tail of the offal auger is placed below the water level of a wet well. Allowing the tail of the auger to be submerged causes the auger flights to act as a grinder as it moves offal into the trailer. Extremely high strength wastewater then drains from the offal and loads the waste stream. Many times this problem can be solved by simply lowering the water level in wet wells by adjusting the float switches.

Importance of Waste Stream Analysis

Wastewater analysis is important not only for environmental purposes but also to determine plant efficiency.

A further processor was discharging 100,000 gallons of wastewater per day with a BOD concentration of 4,000 mg/L. This discharge represented approximately 6500 pounds of product being sent to the waste stream each day. All of the components received by further processing are edible. High strength waste streams indicate excessive product loss.

A combined slaughter-further processing plant was concerned that excessive fat and oil was killing the grass in the irrigation spray fields. Inspection of the wastewater pretreatment plant showed 15,000 gallons of cooking oil on the top of the clarifier. The processor's primary concern should have been why two tractor trailer loads of cooking oil was discharged in the waste stream rather than its effect on the spray fields.

To determine the organic load being discharged to two types of data are required; a measure of the flow volume and the concentration of organics in the waste stream. The equations and calculations in Table 2 defines the process.

Table 2*. Method to Determine Waste Stream Loading

---

1. Calculation:

$$\frac{\text{Flow volume in gallons}}{1{,}000{,}000} \times 8.34^{*} \times \text{concentration of pollutants in mg/L} = \text{pounds}$$

*1 gallon of water weighs 8.34 pounds

2. Example calculation:

A broiler processing plant processes 1,250,000 birds per week using five gallons per bird analysis of the waste stream measured a Total Volatile Solids (TVS-organic matter) of 2,000 mg/L.

$$\frac{6{,}250{,}000}{1{,}000{,}000} \times 8.34 \times 2{,}000 \text{ mg/L TVS} = 104{,}250 \text{ pounds organic matter}$$

$$\frac{104{,}250 \text{ pounds TVS}}{1{,}250{,}000 \text{ birds}} = 0.08 \text{ pounds organic matter per bird}$$

3. Broilers are approximately 75 per cent water, TVS measures organics on a dry weigh basis, therefore, 104,250 pounds of organic matter represents 417,000 pounds of live weight. If these 1,250,000 birds averaged 4.5 pounds then 5,625,000 pounds of live weight was processed and 417,000 pounds (7.4 percent) went to the waste stream.

In the past, water and wastewater were viewed as a dead cost of doing business. With increased environmental pressure, efficient wastewater management can not only reduce these headaches but also improve yields.

CLEAN WATER ACT: PRESENT AND FUTURE

Maryann Gerber
NPS Coordinator
EPA Region IV
345 Courtland Street, NE
Atlanta, GA 30365

Nonpoint source (NPS) pollution is the largest remaining cause of water quality degradation in the U.S. Agriculture is the nation's largest source contributing to NPS pollution. States reported 41 percent of their NPS problems were due to agricultural sources.

Data from states indicate that about one-third of agricultural-related NPS pollution is caused by animal waste runoff from feedlots, pasture lands and animal holding areas.

Despite promulgation and implementation of regulations in the 1970's under EPA's NPDES program and development and implementation of State NPS programs in the 1980's state reports on water quality (NPS Assessment and 305[b]) continue to identify animal operations as a significant cause of water quality impairment.

NONPOINT SOURCE POLLUTANTS

The primary pollutants from agricultural nonpoint sources are nutrients, sediment, animal wastes, salts and pesticides. Agricultural activities also have the potential to directly impact the habitat of aquatic species through physical disturbances caused by livestock, equipment, or through the management of water.

The focus for nonpoint sources in the poultry and egg industry is animal wastes. The following pollutants may be contained in manure, associated bedding materials and dead animals and could be transported by runoff water and process wastewaterfrom confined animal facilities: oxygen demanding substances; nitrogen and phosphorus and other major/minor nutrients; organic solids; salts; bacteria, viruses and other microorganisms; and sediments.

Fish kills may result from runoff, wastewater or manure entering surface waters due to excess ammonia or dissolved oxygen depletion. The decomposition of organic materials can deplete dissolved oxygen supplies in water resulting in anoxic or anaerobic conditions (without oxygen). Methanes, amines and sulfides are produced in anaerobic waters causing the water to acquire an unpleasant odor, taste and appearance. Such waters can be unsuitable for drinking, fishing or other recreational uses.

Solids deposited in waterbodies can accelerate eutrophication through the release of nutrients over extended periods of time. Because of the high nutrient and salt content of manure and runoff from manure-covered areas, contamination of ground water can be a problem if storage structures are not constructed to minimize seepage.

Animal diseases can be transmitted to humans through contact with animal feces.

CLEAN WATER ACT - PRESENT

In the field of water pollution control, EPA through the provisions of the Clean Water Act (CWA), has historically distinguished between point and nonpoint sources of water pollution.

The term "point source" means any discernible, confined and discrete conveyance including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural stormwater discharges and return flows from irrigated agriculture. (CWA Section 502[14]).

Any discharges to waters of the U.S. that are <u>not</u> EPA defined point sources (i.e., as defined above and subject to CWA Section 402 or 404 permits) are generally considered to be nonpoint sources. So nonpoint source is generally considered storm water runoff from agricultural and silvicultural operations, construction sites, small urban areas, land disposal activities such as sludge spreading and septic systems, mining activities, and hydromodification.

There are always exception to the rule. For example, concentrated animal feeding operations (CAFO's) of a certain size are defined as point sources. As such, the National Pollutant Discharge Elimination System (NPDES), established by the CWA, authorizes EPA, or states to which EPA has delegated NPDES authority, to issue permits for these operations. The permits may be called NPDES permits, Section 402 permits or point source permits.

CAFO's of lesser size are generally considered nonpoint sources not subject to NPDES permitting requirements. However, EPA or states with delegated NPDES authority, may issue permits to any CAFO that has a direct discharge to navigable waters that causes significant water quality problems (i.e., violates water quality standards).

On October 1992, the new storm water NPDES permit requirements went into effect. These regulating require some discharges EPA had been treating as nonpoint sources to be treated as point source.

For the poultry and egg industry storm water permits might be applicable in the case of processing plants where activities that create sources of pollutants are not protected from rainfall. You need to check with the appropriate state or EPA if you are not familiar with this program.

NONPOINT SOURCE PROGRAMS TO ADDRESS ANIMAL WASTES

A variety of State and Federal NPS programs address animal waste problems associated with smaller animal operations not covered by the NPDES permit program and animal operations that are not confined (i.e., pastured livestock). These programs can address the cumulative effect of small operations, which can be significant.

One such program is Section 319 of the CWA which requires states to assess NPS problems and develop management programs to address NPS problems. Section 319 is a non-regulatory federal program. In other words, it requires no permits with standard limits under the provisions of the CWA.

The 319 program does however, allow for state and local agencies to develop and implement regulatory programs they deem necessary to control identified NPS pollution through the State's NPS Management Program.

Section 319 provides grant funds for states to implement their EPA-approved NPS Management Programs. The annual appropriation for Section 319 has been about $500 million annually since FY90. The FY94 Presidential budget proposes $80 million for Section 319, a significant increase. Analysis of use of past grant funds indicates that agricultural projects (all categories) received the most funds.

Section 319 provides funds to states to support:

1. Information and education programs;
2. Technical assistance for installation of NPS controls;
3. Cost sharing for implementation of NPS controls on a demonstration basis; and
4. Support for development and implementation of state and local regulatory programs such as animal wastes regulations, etc.

EPA Region IV has provided Section 319 funding for a number of poultry waste demonstration projects in Alabama, Florida, Georgia, Kentucky, Mississippi and South Carolina. These projects include dry stacks, dead chicken composters, manure composting alternatives, etc.

The major water quality problem related to poultry production operations that EPA and states are experiencing is related to too much "waste" for the land available for application. This results in increased levels of nutrients in shallow ground water and potential for surface water impairment.

COASTAL ZONE ACT REAUTHORIZATION AMENDMENTS OF 1990

On November 5, 1990, the Coastal Zone Act Reauthorization Amendments (CZARA) of 1990, commonly Called CZARA, were signed into law. This law requires states and territories with approved coastal zone management programs to develop a Coastal Nonpoint Pollution Control Program. EPA and NOAA jointly administer the new requirements and this January we issued final guidance for the program -- management measures guidance and program guidance.

CZARA requires EPA, in consultation with other federal agencies, to issue guidance on NPS "management measures" which are the equivalent of technology-based controls for nonpoint sources. The law required the management measures to represent "best available technology" for reducing NPS pollution of coastal waters and to be "economically achievable."

Management measures have been developed for a variety of nonpoint sources including agriculture. Of greatest interest to those of you here today in the poultry and egg industry are the management measures associated with agriculture. Agriculture comprises Chapter 2 in the management measures guidance (big blue book). The agricultural chapter of the management measures guidance addresses management of confined animal facilities as well as erosion and sediment control and nutrient and pesticide management.

CZARA requires states to develop coastal nonpoint pollution programs in the state designated coastal zone. This program must provide implementation of management measures "in conformity with" the management measures guidance within 30 months of issuance of EPA's final guidance (i.e., by July 1995). State coastal nonpoint programs are also required to contain "enforceable policies" to implement the programs. Joint EPA/NOAA program implementation guidance was issued in January which defines more clearly how the programs are to be developed and implemented. Both EPA and NOAA will be responsible for approving State Coastal Nonpoint Pollution Programs.

CZARA requires states to implement their Coastal Nonpoint Pollution Programs within 30 months of EPA/NOAA approval (i.e., by January 1999). This means all identified sources in the coastal zone must have installed appropriate management measures consistent with the approved program by January 1999.

MANAGEMENT MEASURES FOR CONFINED ANIMAL FACILITIES

The final management measures guidance takes a two-tiered approach to the management for confined animal facilities in recognition of the potential economic impacts on smaller producers. The two tiers are related to degree of stringency for measures applying to large and small facilities.

The more stringent management measures applies to all new facilities and existing facilities over a certain size (e.g., more than 15,000 layers or broilers, 13,750 turkeys, 300 head of beef, 70 head of dairy cows, 200 swine, etc.). This measure requires these confined animal facilities to store wastewater and runoff caused by storms up to and including the 25-year, 24-hour frequency storm.

The second management measure applies to smaller existing facilities (e.g., 5,000-14,999 layers or broilers, 5,000-13,749 turkeys, 50-299 head of beef, 20-69 head of dairy cows, etc.). For these smaller existing facilities the management measure is to minimize the discharge of wastewater and runoff from the facility through such practices as covered waste storage structures, grassed water ways, filter strips, or other practices that reduce runoff from concentrated animal waste areas.

Both measures require the large and small facilities to manage stored runoff and solids with proper waste utilization and disposal methods. This can normally be achieved with by developing and implementing nutrient management plans.

Small facilities below the cut-offs listed ahbove are exempt from the confined animal facility management measure. Additionally, states have some flexibility to exclude sources that they can demonstrate do not contribute to significant loads to coastal waters. States also have the flexibility to develop alternative management practices as long as they are equally effective as the management measure.

Confined animal facilities are not subject to the management measure if they are required to apply for and obtain permits under 40 DFR 122.23 (i.e., NPDES permitted facilities).

CLEAN WATER ACT - FUTURE

There has been a lot of activity on reauthorization of the Clean Water Act this year. However, it now appears the Clean Water Act will not be passed this year and will be back next year for consideration. The most likely bill that will be addressed by Congress will be a version of S. 1114, the Baucus/Chafee Bill, so the discussion will focus on the provisions of this bill as these will likely resurface next year.

S. 1114

S. 1114 was introduced on June 15, 1993 by Senators Max Baucus (D-MT), Chairman of the Senate Environment and Public Works Committee, and John Chafee (R-RI), ranking minority member of that committee. S. 1114 includes major new provisions for nonpoint source control and also watershed implementation. The provisions of S. 1114 have some similarities with the CZARA requirements now applicable only in coastal areas. S. 1114 provides for:

- States to submit lists of impaired waters with 2 years and update the lists every 5 years;

- States are to submit revised NPS Management Programs consistent with EPA guidance (similar to CZARA management measures guidance) within 2½ years - <u>First Round Implementation</u>;

- Revised State NPS Management Programs are to implement management measures or site-specific plans for all new sources and existing sources impacting listed impaired waters as expeditiously as possible but within 3 years of program approval.

- Second Round Implementation - Seven years after enactment of the second update of the States NPS Management Programs including enforceable policies;

- In the second round, site specific plans may only be used in lieu of management measures where EPA has approved a watershed plan under the new CWA Section 321;

- Authorized 319(h) grant funds are increased substantially from $300 million to FY95 to $600 million in FY2000;

This bill also establishes a new voluntary Section 321 for watershed management. The provisions of this section are:

- States may designate watersheds under this program;

- States may conduct watershed planning activities;

- States seek approval of plans from EPA; and

- Approved state plans may obtain funding of watershed implementation activities under 319 and the State Revolving Fund.

SUMMARY

Clean Water Act will be on the agenda for reauthorization next year.

More needs to be done in the arena of controlling nonpoint sources, especially in the area of agriculture. This allows for plenty of opportunity for all parties to cooperate on solving water quality issues related to the poultry industry.

EPA and agriculture, both industry, agency and operators need to develop a workable solution that will lead to real water quality protection which provides for a continued economic basis.

CLEAN AIR ACT

Pamela Adams
U.S. Environmental Protection Agency
Atlanta, GA

This fact sheet provides an overview of the refrigerant recycling requirements of section 608 of the Clean Air Act, 1990, as amended (CAA), including final regulations published on May 14, 1993 (58 FR 28660), and the prohibition on venting that became effective on July 1, 1992.

OVERVIEW

Under section 608 of the CAA, EPA has established regulations that:

- Require service practices that maximize recycling of ozone-depleting compounds (both chlorofluorocarbons [CFCs] and hydrochlorofluorocarbons [HCFCs]) during the servicing and disposal of air conditioning and refrigeration equipment.

- Set certification requirements for recycling and recovery equipment, technicians, and reclaimers.

- Restrict the sale of refrigerant to certified technicians.

- Require persons servicing or disposing of air conditioning and refrigeration equipment to certify to EPA that they have acquired recycling or recovery equipment and are complying with the requirements of the rule.

- Establish safe disposal requirements to ensure removal of refrigerants from goods that enter the waste stream with the charge intact (e.g., motor vehicle air conditioners, home refrigerators, and room air conditioners).

THE PROHIBITION ON VENTING

Effective July 1, 1992, section 608 of the Act prohibits individuals from knowingly venting ozone-depleting compounds used as refrigerants into the atmosphere while maintaining, servicing, repairing, or disposing of air conditioning or refrigeration equipment. Only four types of releases are permitted under the prohibition:

1. "De minimis" quantities of refrigerant released in the course of making good faith attempts to recapture and recycle or safely dispose of refrigerant.

2. Refrigerants emitted in the course of normal operation of air conditioning and refrigeration equipment (as opposed to during the maintenance, servicing, repair, or disposal of this equipment) such as from mechanical purging and leaks. However, EPA is requiring the repair of substantial leaks.

3. Mixtures of nitrogen and R-22 that are used as holding charges or as leak test gases, because of these cases, the ozone-depleting compound is not used as a refrigerant. However, a technician may not avoid recovering refrigerant by adding nitrogen to a charged system; before nitrogen is added, the system must be evacuated to the appropriate level in Table 1. Otherwise, the CED or HCFC vented along with the nitrogen will be considered a refrigerant. Similarly, pure CFCs or HCFCs released from appliances will be presumed to be refrigerants, and their release will be considered a violation of the prohibition on venting.

4. Small releases of refrigerant which result from purging hoses or from connecting or disconnecting hoses to charge or service appliances will not be considered violations of the prohibition on venting. However, recovery and recycling equipment manufactured after November 15, 1993, must be equipped with low-loss fittings.

REGULATORY REQUIREMENTS

Service Practice Requirements

1. Evacuanon Requirements. Beginning July 13, 1993, technicians are required to evacuate air-conditioning and refrigeration equipment to established vacuum levels. If the technician's recovery or recycling equipment is manufactured any time before November 15, 1993, the air conditioning and refrigeration equipment must be evacuated to the levels described in the first

column of Table 1. If the technician's recovery or recycling equipment is manufactured on or after November 15, 1993, the air conditioning and refrigeration equipment must be evacuated to the levels described in the second column of Table 1, and the recovery or recycling equipment must have been certified by an EPA approved equipment testing organization (see Equipment Certification, below).

Technicians repairing small appliances, such as household refrigerators, household freezers, and water coolers, are required to recover 80-90 percent of the refrigerant in the system, depending on the status of the system's compressor.

Table 1. Required Levels of Evacuation for Appliances Except for Small Appliances, MVACS, and MVAC-Like Appliances

	Inches of mercury vacuum* Using equipment manufactured:	
Type of Appliance	Before Nov. 15, 1993	On or after Nov. 15, 1993
HCFC-22 appliance** normally containing less than 200 pounds of refrigerant	0	0
HCFC-22 appliance** normally containing 200 pounds or more of refrigerant	4	10
Other high-pressure appliance** normally containing less than 200 pounds of refrigerant (CFC-12, -500, -502, -114)	4	10
Other high-pressure appliance** normally containing 200 pounds or more of refrigerant (CFC-12, -500, -502, -114	4	15
Very high pressure appliance (CFC-13, -503	0	0
Low-pressure appliance (CFC-11, HCFC-123)	25	25 mm Hg absolute

*Relative to standard atmospheric pressure of 29.9^{o} Hg.
**Or isolated component of such an appliance.

2. Exceptions to Evacuation Requirements. EPA has established limited exceptions to its evacuation requirements for 1) repairs to leaky equipment and 2) repairs that are not major and that are not followed by an evacuation of the equipment to the environment.

   If, due to leaks, evacuation to the levels in Table 1 is not attainable, or would substantially contaminate the refrigerant being recovered, persons opening the appliance must:

   - isolate leaking from non-leaking components wherever possible;

   - evacuate non-leaking components to the levels in Table 1; and

   - evacuate leaking components to the lowest level that can be attained without substantially contaminating the refrigerant. This level cannot exceed 0 psig.

   If evacuation of the equipment to the environment is not to be performed when repairs are complete, and if the repair is not major, the appliance must:

   - be evacuated to at least 0 psig before it is opened if it is a high- or very high-pressure appliance; or be pressurized to 0 psig before it is opened if it is a low-pressure appliance. Methods that require subsequent purging (e.g., nitrogen) cannot be used.

   "Major" repairs are those involving removal of the compressor, condenser, evaporator, or auxiliary heat exchanger coil.

3. Reclamation Requirement. EPA has also established that refrigerant recovered and/or recycled can be returned to the same system or other systems owned by the same person without restriction. If refrigerant changes ownership, however, that refrigerant must be reclaimed (i.e., cleaned to the ARI 700 standard of purity and chemically analyzed to verify that it meets this standard). This provision will expire in May 1995, when it may be replaced an off-site recycling standard.

Equipment Certification

The Agency has established a certification program for recovery and recycling equipment. Under the program, EPA requires that equipment manufactured on or after November

15, 1993, be tested by an EPA-approved testing organization to ensure that it meets EPA requirements. Recycling and recovery equipment intended for use with air conditioning and refrigeration equipment besides small appliances must be tested under the ARI 740-1993 test protocol, which is included in the final rule as Appendix B. Recovery equipment intended for use with small appliances must be tested under either the ARI 740-1993 protocol or Appendix C of the final Rule. The Agency is requiring recovery efficiency standards that vary depending on the size and type if air conditioning or refrigeration equipment being serviced. For recovery and recycling equipment intended for use with air-conditioning and refrigeration equipment besides small appliances, these standards are the same as those in the second column of Table 1. Recovery equipment intended for use with small appliances must be able to recover 90 percent of the refrigerant in the small appliance when the small appliance compressor is operating and 80 percent of the refrigerant in the small appliance when the compressor is not operating.

Equipment Grandfathering

Equipment manufactured before November 15, 1993, including home-made equipment, will be grandfathered if it meets the standards in the first column of Table 1. Third-party testing is not required for equipment manufactured before November 15, 1993, but equipment manufactured on or after that date, including home-made equipment, must be tested by a third-party (see Equipment Certification above).

Refrigerant Leaks

Owners of equipment with charges of greater than 50 pounds are required to repair substantial leaks. A 35 percent annual leak rate is established for the industrial process and commercial refrigeration sectors as the trigger for requiring repairs. An annual leak rate of 15 percent of charge per year is established for comfort cooling chillers and all other equipment with a charge of over 50 pounds other than industrial process and commercial refrigeration equipment. Owners of air conditioning and refrigeration equipment with more than 50 pounds of charge must keep records of the quantity of refrigerant added to their equipment during servicing and maintenance procedures.

Mandatory Technician Certification

EPA has established a mandatory technician certification program. The Agency has developed four types of certification:

- For servicing small appliances (Type I).
- For servicing or disposing of high- or very high-pressure appliances, except small appliances and MVACs (Type II).
- For servicing or disposing of low-pressure appliances (Type III).
- For servicing all types of equipment (Universal).

Persons removing refrigerant from small appliances and motor vehicle air conditioners for purposes of disposal of these appliances do not have to be certified.

Technicians are required to pass an EPA-approved test given by an EPA-approved certifying organization to become certified under the mandatory program. Technicians must be certified by November 14, 1994. EPA expects to have approved some certifying organizations by September of this year. The Stratospheric Ozone Hotline will distribute lists of approved organizations at that time.

EPA plans to "grandfather" individuals who have already participated in training and testing programs provided the testing programs 1) are approved by EPA and 2) provide additional, EPA-approved materials or testing to these individuals to ensure that they have the required level of knowledge.

Although any organization may apply to become an approved certifier, EPA plans to give priority to national organizations able to reach large numbers of people. EPA encourages smaller training organizations to make arrangements with national testing organization to administer certification examinations at the conclusion of their courses.

Refrigerant Sales Restrictions

Under Section 609 of the Clean Air Act, sales of CFC-12 in containers smaller than 20 pounds are now restricted to technicians certified under EPA's motor vehicle air conditioning regulations. persons servicing appliances other than motor vehicle air conditioners may still buy containers of CFC-12 larger than 20 pounds.

After November 14, 1994, the sale of refrigerant in any size container will be restricted to technicians certified wither under the program described in Technician Certification above or under EPA's motor vehicle air conditioning regulations.

Certification by Owners of Recycling and Recovery Equipment

EPA is requiring that persons servicing or disposing of air-conditioning and refrigeration equipment certify to EPA that they have acquired (built, bought, or leased) recovery or recycling equipment and that they are complying with the applicable requirements of this rule. This certification must be signed by the owner of the equipment or another responsible officer and sent to the appropriate EPA Regional Office by August 12, 1993. A sample form for this certification is attached. Although owners of recycling and recovery equipment are required to list the number of trucks based at their shops, they do not need to have a piece of recycling or recovery equipment for every truck.

Reclaimer Certification

Reclaimers are required to return refrigerant to the purity level specified in ARI Standard 700-1988 (an industry-set purity standard) and to verify this purity using the laboratory protocol set forth in the same standard. In addition, reclaimers must release no more than 1.5 percent of the refrigerant during the reclamation process and must dispose of wastes properly. Reclaimers must certify by August 12, 1993, to the Section 608 Recycling Program Manager at EPA headquarters that they are complying with these requirements and that the information given is true and correct. The certification must also include the name and address of the reclaimer and a list of equipment used to reprocess and to analyze the refrigerant.

EPA encourages reclaimers to participate in third-party reclaimer certification programs, such as that operated by the Air Conditioning and Refrigeration Institute (ARI). Third-party certification can enhance the attractiveness of a reclaimer's product by providing an objective assessment of its purity.

MVAC-Like Appliances

Some of the air conditioners that are covered by this rule are identical to motor vehicle air conditioners (MVACs), but they are not covered by the MVAC refrigerant recycling rule (40 CFR Part 82 Subpart B) because they are used in vehicles that are not defined as "motor vehicles." These air conditioners include many systems used in construction equipment, farm vehicles, boats, and airplanes. Like NVACs in cars and trucks, these air conditioners typically contain two or three pounds of CFC-12 and use open-drive compressors to cool the passenger compartments of vehicles. (Vehicle air conditioners utilizing HCFC-22 are not included in this group and are therefore subject to the requirements outlined above for HCFC-22 equipment.) EPA is defining these air conditioners as "MVAC-like appliances" and is applying the MVAC rule's requirements for the certification and use of recycling and recovery equipment to them. That is, technicians servicing MVAC-like appliances must "properly use" recycling or recovery equipment that has been certified to meet the standards in Appendix A to 40 CFR Part 82, Subpart B. In addition, EPA is allowing technicians who service MVAC-like appliances to be certified by a certification program approved under the MVAC rule, if they wish.

Safe Disposal Requirements

Under EPA's rule, equipment that is typically dismantled on-site before disposal (e.g., retail food refrigeration, cold storage warehouse refrigeration, chillers, and industrial process refrigeration) has to have the refrigerant recovered in Accordance with EPA's requirements for servicing. However, equipment that typically meters the waste stream with the charge intact (e.g., motor vehicle air conditioners, household refrigerators and freezers, and room air conditioners) is subject to special safe disposal requirements.

Under these requirements, the final person in the disposal chain (e.g., a scrap metal recycler or landfill owner) is responsible for ensuring that refrigerant is recovered from equipment before the final disposal of the equipment. However, persons "up-stream" can remove the refrigerant and provide documentation of its removal to the final person if this is more cost-effective.

The equipment used to recover refrigerant from appliances prior to their final disposal must meet the same "performance standards" as equipment used prior to servicing, but it does not need to be tested by a laboratory. This means that self-built equipment is allowed as long as it meets the performance requirements. For MVACs and MVAC-like appliances, the performance requirement is 102 mm of mercury vacuum and for small appliances, the recover equipment performance requirements are 90 percent efficiency when the appliance compressor is operational, and 80 percent efficiency when the appliance compressor is not operational.

Technician certification is not required for individuals removing refrigerant from appliances in the waste stream.

The safe disposal requirements are effective on July 13, 1993. The equipment must be registered or certified with the Agency by August 12, 1993. A sample form is attached.

Major Recordkeeping Requirements

Technicians servicing appliances that contain 50 or more pounds of refrigerant must provide the owner with an invoice that indicates that amount of refrigerant added to the appliance. Technicians must also keep a copy of their proof of certification at their place of business.

Owners of appliances that contain 50 or more pounds of refrigerant must keep servicing records documenting the data and type of service, as well as the quantity of refrigerant added.

Wholesalers who sell CFC and HCFC refrigerants must retain invoices that indicate the name of the purchaser, the date of sale, and the quantity of refrigerant purchased.

Reclaimers must maintain records of the names and addresses of persons sending them material for reclamation and the quantity of material sent to them for reclamation. This information must be maintained on a transactional basis. Within 30 days of the end of the calendar year, reclaimers must report to EPA the total quantity of material sent to them that year for reclamation, the mass of refrigerant reclaimed that year, and the mass of waste products generated that year.

Hazardous Waste Disposal

If refrigerants are recycled or reclaimed, they are not considered hazardous under federal law. In addition, used oils contaminated with CFCs are not hazardous on the condition that:

- They are not mixed with other waste.
- They are subjected to CFC recycling or reclamation.
- They are not mixed with used oils from other sources.

Used oils that contain CFCs after the CFC reclamation procedure, however, are subject to specification limits for used oil fuels if these oils are destined fur burning. Individuals with questions regarding the proper handling of these materials should contact EPA's RCRA Hotline at 800-424-9346 or 703-920-9810.

ENFORCEMENT

EPA is performing random inspections, responding to tips, and pursuing potential cases against violators. Under the

Act, EPA is authorized to assess fines of up to $25,000 per day for any violation of these regulations.

PLANNING AND ACTING FOR THE FUTURE

Observing the refrigerant recycling regulations for section 608 is essential in order to conserve existing stocks of refrigerants, as well as to comply with Clean Air Act requirements. However, owners of equipment that contains CFC refrigerants should look beyond the immediate need to maintain existing equipment in working order. EPA urges equipment owners to act now and prepare for the phaseout of CFCs, which will be completed by January 1, 1996. Owners are advised to begin the process of converting or replacing existing equipment with equipment that uses alternative refrigerants.

To assist owners, suppliers, technicians and others involved in comfort chiller and commercial refrigeration management, EPA has published a series of short fact sheet and expects to produce additional material. Copies of material produced by the EPA Stratospheric Protection Division are available from the Stratospheric Ozone Information Hotline (see hotline number below).

FOR FURTHER INFORMATION

For further information concerning regulations related to stratospheric ozone protection, please call the Stratospheric Ozone Information Hotline: 800-292-1996. The Hotline is open between 10:00 am and 4:00 pm, Eastern Time.

Table 2. Major Recycling Rule Compliance Dates

*Date after which owners of equipment containing more than 50 pounds of refrigerant with substantial leaks must have such leaks repaired.	June 14, 1993
*Evacuation requirements go into effect. *Recovery and recycling equipment requirements to into effect.	July 13, 1993
*Owners of recycling and recovery equipment must have certified to EPA that they have acquired such equipment and that they are complying with the rule. *Reclamation requirement goes into effect.	August 12, 1993
*All newly manufactured recycling and recovery equipment must be certified by an EPA-approved testing organization to meet the requirements in the second column of Table 1.	November 15, 1993
*All technicians must be certified. *Sales restriction goes into effect.	November 14, 1994
*Reclamation requirement expires.	May 14, 1995

OVERVIEW OF WATER RECYCLING IN PROCESSING

R. Eugene Carawan
Department of Food Science
North Carolina State University
Raleigh, NC 27695-7624

The food industry is one of the largest and most important contributors to the world economy. The food processing industry uses vast quantities of water. As an example, the animal processing industries in the United States use over 100,000,000,000 gallons of water per year. The larger volumes of water used in the animal processing industries and equally large waste loads generated have resulted in many environmental problems. These problems include regional water shortages, pollution problems, the increasing cost of suitable water, and the increasing cost of wastewater treatment and disposal. These will tend to make process water recycling, processing wastewater effluent treatment with reclamation and reuse, and daily water conservation increasingly desirable both economically and environmentally.

There are two solutions to the problem of controlling water use in food processing plants. The first is in-plant water reduction. The second method is wastewater reuse after treatment. This method is of particular interest within the food processing industry since it is with these technologies that significant reductions in water supply needs can be achieved.

Water is used in a variety of operations in poultry processing plants including: washing, conveying, scalding, chilling, cooking, sanitation, etc. Although, at present in the United States, water reuse in USDA inspected plants is allowed only under prescribed conditions, many opportunities exist for water reuse. Specific concerns involving water reuse include water quality which is critical to food product quality and consumer safety. Experimental systems are now being studied to allow the total recycling and reuse of treated process water in animal processing plants. One meat slaughtering plant in the USA has recently (1994) received approval from USDA to utilize reconditioned process water in the plant for all uses until the carcass is opened.

The processing of animals and animal products is a large component of the food industry. The various segments of the poultry industry are a large component of the animal processing industry. Some large poultry processing plants use in excess of 5,000,000 gallons of water per day. There is an increasing awareness of the need to responsibly manage and protect our environment. Because facing environmental challenges is crucial to the poultry industry economic strength and employment, environmentally clean processing technologies are needed to help conserve our vital natural resources without any reduction in productivity.

IN-PLANT WATER REDUCTION

Since the 1970's, many efforts have been directed to in-plant modifications resulting in water and wastewater reduction. In-plant changes for poultry processing water conservation include changes such as using nozzles on clean-up hoses, using nozzles instead of holes drilled in pipes for washing, avoiding unnecessary water overflows from equipment, using low-volume high-pressure washing systems, and installing devices to limit flow except when needed. For example, it has been reported that water use can be reduced 67% by using low volume-high pressure sprays.

WASTEWATER REUSE AND RECYCLING

Within USDA inspected food processing plants there are three general areas for potential use of renovated process waters, listed here in order of increasing risk of product contamination:

1. areas where the water would not contact the finished or unprotected product but which may contact the product in initial processing stages or may contact the containerized product with little likelihood of entering the processed food package, such as condensers, initial fluming, initial washing and cooling.

2. areas where water directly contacts the product before, during and after processing and where the water could be incorporated into the finished product package in small amounts, such as scalding, product washing, equipment washing, chilling and spraying the equipment and product prior to package filling, and

3. areas where water would be directly incorporated into the product and the product containers.

Most renovated process water will probably be limited to reuse in areas 1 or 2. Reclaimed water must meet the requirements recommended by EPA and acceptible to FDA. These requirements are: (a) that the water be free of micro-organisms of public health significance; (b) that the water contain no chemicals in concentrations toxic or otherwise harmful to man; (c) that the water be free of any materials or compounds which could impart discoloration, off-flavor, or off-odor to the product, or otherwise adversely affect its quality, (d) that the appearance and content of the water be acceptable from an aesthetic viewpoint.

One water reuse method is water recycling. There are two recycling practices within processing plants. One is process recycle. Recycling can be made within the particular process such as poultry chiller water recycling where the used water is recycled following some appropriate treatment, such as filtering, thermal processing, or disinfection, for use in the same process. Another is counter-current recycle where used water from one process is recycled counter to the product flow to processes having lower quality requirements, such as utilization of chiller overflow waters for scalding and defeathering. In-plant water recycling practices are well documented but little used in USDA processing plants.

Reclamation of a food processing effluent for reuse will entail some treatment or combination of treatment processes. The treatment can be classified as (1) simple reclamation treatment; (2) conventional reclamation treatment; and (3) advanced reclamation treatment.

More than a decade ago, a two-year demonstration project determined the feasibility of reclaiming poultry processing effluent for reuse. The scientists found that the inorganic and physio-chemical characteristics of the renovated water consistently met EPA primary drinking water standards. The scientists determined the ability and reliability of the water reclamation system to deliver water, mixed with the well water source (50/50), that is safe for reuse in processing poultry. Even though the results were acceptable, water reuse was disallowed at the time. The recent success of the meat plant approved for using such water indicates an acceptance of technology that was unacceptable previously.

One study found gizzard splitters operated with water recycled without bactericidal treatment could be used with little effect on the product. EPA studies involving chilling, prechilling, washing, and scalding poultry in Egyptian plants found no difference in carcass quality when either one-third of the process water came from potable or from recycled water that had been screened and filtered through diatomaceous earth. Technologies for the recycling of chiller water have been reported in a number of studies. The value of reusing poultry chiller water in the US has been estimated to exceed $26 million dollars annually.

An attempt was made in 1976 to provide USDA/Food Safety and Inspection Service (FSIS) with documented evidence of the effect of 0, 50, 75% reduction of chiller overflow on carcass microbiological and hygienic quality. The study included turkeys, broilers, and cornish hens.

A Canadian study is maybe the most comprehensive study provided yet on water reuse in a poultry processing plant. A "closed-loop" system provided only for replacement of water that left the chiller by carcass uptake and spillage. With the use of Powdered Activated Carbon, antibiotics, and a very sophisticated filtering system, they demonstrated that chiller water could be reused up to 2 weeks with no detrimental effect on carcass quality.

SUMMARY

1. The poultry processing industries must recognize and accept the fact that adequate handling and treatment of wastewater is a necessary cost of doing business.

2. Water use in the plant should be reduced to the lowest volume possible which still allows an efficient and sanitary operation.

3. It is most effective to combine in-plant water reduction methods with the wastewater reuse method in food processing industry.

4. The need for ever improving wastewater treatment processes and recycling technology will continue to increase.

5. The reuse of a reclaimed processing effluent in a food processing plant should be directed to specific processing areas believed most suitable for utilizing reclaimed water and thus minimize the risk of product contamination.

6. The obstacles to implementing reuse projects in food processing are mainly (a) cost--treatment cost, modification cost; (b) information dissemination and education; and (c) water-quality and health issues.

7. Reclamation and reuse of the processing effluent has only been recently endorsed by USDA, EPA, and FDA. The agencies are only now beginning to assess the potential for reclamation and reuse in the food processing industry.

Recent studies in Europe have indicated that water reuse, water recycling, and process redesign may allow processing of broilers with only 0.26 gallons of water. Broiler processing plants in the United States use more than 30,000,000,000 gallons of water annually. If all US plants could achieve the savings suggested in the European studies, the annual savings could exceed $138,000,000 (assuming water and wastewater costs are $5/1,000 gallons).

Food and poultry scientists and others need to address environmental issues such as water use and reuse to strengthen the ability of the poultry industries to protect the environment, assure a safe and nutritious food supply, and compete in the world economy.

FSIS WATER POLICY INITIATIVES

Michael J. Rose, Ph.D.
Deputy Director
Facilities, Equipment and Sanitation Division
Food Safety Inspection Service, USDA
Washington, DC 20250

The Food Safety Inspection Service has four initiatives to facilitate water conservation through the reuse of solutions.

The first initiative is an ongoing one that relates to the system for evaluating water reuse proposals. To recap the system, briefly, there are a few regulations or issuances, including some related to canning, that directly address water reuse or recirculation. Reuses not covered by these issuances are submitted from the plants through our inspection chain to the Sanitation Branch of the Facilities, Equipment and Sanitation Division. We are the clearinghouse to decide how the proposal will be reviewed further. If it is a simple reuse with an established Agency policy, it may be reviewed by the Sanitation Branch; if closely related to an existing policy, it may be reviewed by the Water Reuse Subcommittee which includes Staff Officers from Divisions throughout the Agency. If there is no existing policy, it is a complex treatment or new technology is involved with the proposal, it may be reviewed by the Water Policy Review Group who are the division directors, or their representatives. When new policy decisions are needed, the Group makes recommendations to the Deputy Administrator for FSIS for decisions. This process provides a thorough, comprehensive review for all proposals.

Second, FSIS has requested that the Agriculture Research Service assist us with several projects directly related to developing applications of technology suitable for water reuse, such as brine microfiltration, and to provide supporting research data or models of reuse systems suitable for identifying safety parameters, then to be used for Agency guidelines. The latter included developing microbial profile data for swine carcasses processed with reconditioned process water in what has been our longest-term and most complex water reuse project and also a new project to develop microbial models for safe extended reuse of brine chilling solutions.

The third initiative is the development of an FSIS directive with guidelines for water reuse. From a technical policy status, the process is nearly completed. The intent of the directive is to provide inspectors and plant management with information on some of the simpler types of reuse, and why, what, and how to submit proposals to be approved. The basic requirements for all reuses are that solution quality is safe for the intended purpose and does not cause any microbial, physical or chemical hazard to product, create any sanitary problems, or interfere with inspection. But there often will be additional specific requirements for most reuses, based on policies developed through the years for particular types of reuses. Examples would be ice reuse or water to be reused for washing livestock pens. Each has its own set of specific water quality and/or sanitary handling criteria. These criteria have been developed and specified so that the approval of simple reuses can be delegated from FESD to Inspection Operations which should expedite the review and approval process. All reuse proposals outside of the guidelines will still be submitted for indepth review starting with the Sanitation Branch in FESD.

In the soon-to-be-completed revision of the Sanitation Handbook, we will also provide additional information to enable submission of better reuse proposals with the goal of expediting our review process too.

The fourth way that we are instituting change with the reuse proposal system is with the review process itself. That is to include some outside review of data and conditions for use by other federal agencies and experts outside of government. This has become necessary with increasingly complex and difficult reuse proposals. The best example is the reuse of reconditioned process water from a swine plant's wastewater treatment system. The Agency laid the groundwork by working with the EPA and FDA to develop guidelines for the safe reuse of reconditioned process water for meat and poultry processing. A breakthrough came in 1992 when EPA and USAID co-published a manual entitled "Guidelines for Water Reuse" that dealt very specifically with the safety criteria necessary for this type of system. By including all of those criteria for an "advanced wastewater reuse system" and the FSIS guidelines, the Agency concerns for this plant have been addressed and satisfied, as all had been met or exceeded, and were accompanied by years of supporting safety data.

But it was decided, because of the policy precedent being set, that a complete review by experts from EPA, FDA and academia would improve the asssurance of safety before finalizing the policy. The review group has unanimously endorsed the comprehensive safeguards and controls on the treatment process and the safety of the water quality for the specified reuses in the plant.

Let me quickly summarize the major requirements for an "advanced wastewater treatment system."

First, that the quality of the reconditioned water is safe and appropriate for its intended use, including adequate installation and operation of fail-safe devices. There must be no compromises with protection of public health related to the use of reconditioned water.

Second, the reliability of the system must be assured in case of power or equipment failures or other problems. The system operator must be trained, qualified, and certified. There must be adequate instruments and control systems installed and functioning for on-line monitoring at all critical control points in the system and alarms to identify process malfunctions quickly. There must be a comprehensive quality assurance program to ensure accurate sampling and laboratory analysis protocol.

Third, the system must be designed and engineered to include all components of an advanced wastewater treatment system. This will include at a minimum the following:

A. A primary physical treatment to remove organic and inorganic solids by sedimentation and skimming. Coagulants and polymers may improve the process. This process does not significantly reduce the microbial, viral, or protozoa/parasitic load in the wastewater.

B. Secondary treatment uses an aerobic biological treatment to remove organic matter by microbial oxidation. This treatment reduces the microbial and viral load in wastewater by over 90%, but not dissolved minerals.

C. Filtration, such as through a sand filter, will remove significant amounts of suspended solids, reduce turbidity, and improve the efficacy of disinfection. And last, disinfection itself is the most important process to insure destruction of microorganisms. Chlorine is the most commonly used water disinfectant. Ozone, chlorine dioxide, and ultraviolet light are also commonly used.

I think that this entire effort has been a major milestone for the Agency and the industry in the area of water conservation and reuse. With all of the concerns about food safety today, I think that FSIS and the industry have in the past and can in the future cooperatively achieve environmentally and fiscally beneficial and scientifically supported programs designed to conserve water through a wide variety of safe solution reuses.

USING RENOVATED PROCESS WATER AT HATFIELD PACKING

R. Eugene Carawan
Department of Food Science
North Carolina State University
Raleigh, NC 27695-7624

and

J. Scott Clemens
Director of Environmental Affairs
Hatfield Quality Meats--2700 Funks Road
Hatfield, PA 19440-2834

Water is a critical natural resource whose conservation is increasingly important to the nation. Meat and poultry processing plants use vast quantities of water to produce their products. Meat processors (beef and pork) and poultry processors (broiler, turkey, egg and duck) probably use more than 100,000,000,000 gallons of water annually in the United States. As concerns over the quality and quantity of water increase, the importance of this use increases. Also, the cost of water has been predicted to increase by 500 percent within the next decade. Water reuse and recycling can be an effective method for conserving water and saving money for meat and poultry processors.

In the Pork Processing Industry, large volumes of water are used daily. These waters after use are usually loaded with large amounts of pollutants such as BOD_5 (biochemical oxygen demand) and suspended solids. When the pollutants are removed from the water, they result in large volumes of solids to be dealt with. If the pollutants are effectively removed from the process wastewater, then this renovated process water when disinfected has the characteristics of potable water. This paper will specifically deal with how Hatfield Quality Meats has removed these solids over the past several years and developed the processes to utilize this renovated process water with USDA approval. In January of 1994, approval was granted by USDA to use renovated process water in the plant in all operations preceeding the opening of the carcass.

Hatfield Quality Meats is a pork processing facility in Southeastern Pennsylvania. Presently, the plant processes 6,500 hogs per day. From these hogs, Hatfield produces over 500 varieties of pork products. In the meat processing industry, large volumes of water are used daily in the total operation. Water is used in processing operations including scalding, dehairing, washing, conveying, brines and cures, intestinal processing, cleaning, chilling and sanitation. Some other typical uses are cooling for refrigeration, boilers, air compressors, premises cleanup, hog pen flushing, truck washing, and various sanitation procedures in the slaughtering operation. On the average, Hatfield treats approximately 700,000 gallons of water per day.

WATER REUSE

The USDA Food Safety and Inspection Service (FSIS) enforces a number of regulations to address the sanitation level of meat and poultry products and these measures rely on the use of significant volumes of water. Although water recycling and reuse are encouraged, proposals requesting approval of such practices receive intense scrutiny to help assure food safety is not compromized.

Although water reuse and recycling is important in a food processing plant from an economic standpoint and environmental pollution standpoint, water conservation and pollution prevention are more cost effective and should be addressed first.

One water reuse method is water recycling. It is used for reducing water consumption. There are two recycling practices within processing plants. One is unit process recycling. Recycling can be made within the particular process of a plant such as poultry chiller where the water is used and then recycled following some appropriate treatment. Treatments that have been studied for poultry chillers include diatamaceous earth filtration and/or disinfection such as chlorination, ozonation, and ultraviolet treatment. Another practice is counter-current recycling where used water from one process is recycled counter to the product flow to processes having lower quality requirements, such as utilization of spent chiller water to the scalder with or without treatment. In-plant water recycling has been practiced by many processors, is well documented, but not generally practiced by most USDA plants.

Within food processing plants there are three general areas for potential use of reclaimed effluent from several operations that have been mixed or from the plant as a whole. USDA has not allowed reuse considerations if human wastes are included. Thus the reuse of renovated process water can be used as listed here in order of increasing risk of product contamination:

1. inedible areas where the water would not contact the finished or unprotected product such as condensers, air compressors, and fluming in offal areas.

2. edible areas where water does not directly contact the product before, during and after processing such as offal flumes.

3. edible areas where water could be directly incorporated into the product and the product containers even in small amounts, such as scalding, product washing, equipment washing, direct cooling of product and spraying the equipment and product prior to packaging.

Most reclaimed water in the past has been limited to reuse in 1 and 2. Hatfield has developed the systems and operational practices to reuse water as explanied in 3.

Such renovated process water must meet the criteria recommended by EPA and accepted by FDA to gain USDA approval. In general, the requirements are: (a) that the water be free of micro-organisms of public health significance; (b) that the water contain no chemicals in concentrations toxic or otherwise harmful to man; (c) that the water be free of any materials or compounds which could impart discoloration, off-flavor, or off-odor to the product, or otherwise adversely affect its quality, (d) that the appearance and content of the water be acceptable from an aesthetic viewpoint.

Reclamation of food processing effluent for reuse will entail some treatment inside or outside of the plant processing area between the initial and subsequent uses of the water. The treatment can be classified as (1) simple reclamation treatment; (2) conventional reclamation treatment; and (3) advanced reclamation treatment. The simple reclamation and conventional reclamation treatment are all in common use in food processing water and wastewater treatment because of simple, low and reasonable costs. However, Hatfield went to the advanced treatment methods to allow expanded use of the renovated wastewater.

Other previous attempts at water reuse in US plants have been minimal. In 1975, an EPA project explored the use of multimedia filters and a chlorination disinfection system to determine the feasibility of reusing the treatment processing effluent in a cannery. This project showed that the biologically treated wastewater could be suitable for reuse within their cannery.

A two-year R&D project in the late 70's to determine the feasibility of reclaiming the poultry processing effluent for reuse found that the inorganic and physio-chemical characteristics of the renovated water consistently met EPA primary drinking water standards. The study concluded that the system had the ability and reliability to deliver water, mixed with the well water source (50/50), that is safe for reuse in processing poultry although the plant was denied permission to use the system on poultry.

Hatfield's USDA Proposal

There are some general criteria that USDA expects in any reuse proposal. For reuse of water that will contact product, some of the general criteria include the following:

A. Meets the following quality guidelines:
   1. Microbial
      a. Total Plate Count (less than 500 cfu/ml)
      b. Coliforms (less than 5% of samples positive)
      c. E. coli (none detectible)
   2. Chemical
      a. Total Organic Carbon (less than 100 mg/l)
   3. Physical
      a. Percent light transmittance (less than 5% of samples greater than 1 NTU with none exceeding 5 NTU)

B. Failsafe device to assure physical quality

C. Testing--methodology and sampling points identified and procedure defined for failure of any test.

The above are general criteria to be used for guidance and have not been formulated as regulations. Each application must specify the criteria and the application will be reviewed based on the merits and the intended use.

Other information critical to any application includes the names of resposible parties, proposed reuse system, amount of reuse and products impacted, supporting data on reuse water quality (assurance that system will perform as intended), monitoring procedures, and controls. The proposal goes through the IIC and the FSED to FSIS. First, it is reviewed by staff. Then the proposal goes through the Water Reuse Committee. Then it proceeds through the Water Policy Review Group. A recommendation is made to the USDA

Deputy Administrator, Science and Technology who recommends appropriate action to the Administrator of FSIS. The administrators have also set up a special technical review panel consisting of three persons--one from FDA, one from EPA, and one academic who perform a final technical review. Each step is repeated until that level is satisfied so as in Hatfield's proposal, years were required before final approval in 1994. In addition to the industry proposal, each level is given comments, questions, and review by USDA personnel from the IIC to the Washington, DC staff.

WATER CONSERVATION AND POLLUTION PREVENTION

The luxury of having unlimited supplies of inexpensive quality water is quickly declining across the United States. Some municipalities providing water and sewer service to meat and poultry processors have increased their charges ninefold over the past 25 years. Future forecasts project a ten-fold increase in water and sewer charges for some areas of the country over the next ten years. The large volumes of water used in meat and poultry processing and equally large waste loads generated have become an important problem for many municipalities. With regional water shortages, pollution problems and new policies on pricing which recognize the economic value of water, daily water conservation and recycling practices by all meat and poultry plants will become a necessity to reduce operational costs. Water conservation and reuse is an issue that goes far beyond the immediate concerns of the USDA and meat and poultry industry. Houston noted that the use of water by the public or any industry has raised important environmental and public health questions that cannot be ignored by any group.

Whenever food, in any form, is handled, processed, packaged and stored, there will always be an inherent generation of wastewater. The quantity of this processing wastewater and its general quality (i.e., pollutant strength, nature of constituents), have both economic and environmental consequences with respect to treatability and disposal.

Dr. Joseph T. Ling of the 3M Company concluded that government, industry and the public are beginning to become aware of the shortcomings of conventional pollution controls, not to mention their cost. Dr. Ling is credited with adopting the pollution prevention pays philosophy that utilizes the concept that the conservation approach should be used to eliminate the causes of pollution before spending money and resources to clean up afterward. Dr. Ling has defined the conservation approach as the practical application of knowledge, methods, and means to provide the most rational use of resources to improve the environment.

Royston recognized pollutants as material residues from industrial, domestic or agricultural processes which are discharged into the environment. He concluded that such materials could either be reused or they should not have been produced in the first place. Royston noted that pollution acts as an indicator of inefficient processes. He concluded that as inefficiencies are reduced, so is pollution reduced.

The economics of treating wastewater from a food processing plant is a result of the amount of product loss in process operations and not recovered as a by-product. The cost of treating this waste material must be considered. The cost for water use is self-evident; however, the cost for treating or pretreating the wastewater depends on its specific characteristics. Two significant characteristics which dictate the cost of treatment are the daily volume of discharge and the relative strength of the wastewater. Other characteristics become important as system operations are affected and specific discharge limits are identified (i.e., BOD_5, COD, TKN, chlorides, and TSS).

The waste load from a meat or poultry plant is a result of hair or feathers, blood, fat, soluble proteins and carbohydrates, bone dust, bits and pieces of meat, and other food materials which are intentionally or inadvertently lost to the sewer system. There are three proven ways to reduce water use, wastewater discharge and waste load. First, one can operate the plant more efficiently. Second, process modifications can be made to reduce water use and waste. Last, pretreatment and treatment steps can be installed to reduce the waste load and even allow for the reuse of this renovated water providing that health and safety concerns are addressed.

Water, sewer and treatment costs can be very significant to any food plant. EPA documents indicate that an 80 percent reduction in these costs have been realized by food plants with effective programs. The reduction of water use and waste in food plants requires well-trained employees, installation of the best technology, and management support and interest.

External restraints on wastewater can influence a food plant to consider water and waste reduction programs. These restraints can include effluent restrictions on selected wastewater parameters such as BOD_5, COD, TSS, pH, chlorides, and flow. More stringent limits or increased production often require costly expansion to the treatment system unless process changes such as water reuse or recycling are implemented.

From the 1970's, many efforts have been directed to in-plant modifications resulting in water and wastewater reduction. Such ideas as using nozzles on clean-up hoses, avoiding unnecessary water overflows from equipment, and using low-volume, high-pressure washing system have been reported but are often not used in many plants. Detailed research projects about the in-plant water and waste reduction in poultry and pork processing were done in the 1970s.

Water Conservation and Pollution Prevention at Hatfield

The management team addressed water conservation and pollution prevention as the most economical technology for reductions. Results were gratifying as water use was reduced by 75 gallons per pig and waste loads were reduced by 40 percent. Practices utilized included putting nozzles on all hoses, replacing holes in pipes with spray nozzles, using high pressure, low volume cleanup systems, and training employees that water was important and should not be wasted.

THE HATFIELD SYSTEM

The Hatfield system consists of primary screening, DAFS with chemical addition, activated sludge system with nutrient removal capability, claifier, and chlorination. After the water is renovated, then the water treatment system is used to polish the water and disinfect. The water treatment processes include sand filters, UV disinfection, and storage and delivery system.

The process waters discharged from the Hatfield facility are typically laden with high amounts of BOD_5 and suspended solids. Table 1 shows a typical monthly analysis of raw and treated process water. All of the water is treated at Hatfield's Advanced Waste Water Treatment Facility, and is either reused at the plant or sent to the local municipal authority. The BOD_5 of the process water averages about 2,585 mg/l with a variation from 1,680 - 4,700 mg/l. The TSS of the process water averages about 1,795 mg/l (1,060 - 3,300 mg/l). The treated process water averages 2.49 mg/l of BOD_5 and 3.49 mg/l of TSS before either discharge to the POTW or the sand filters for reuse.

Table 1. Process Water Parameters--Selected Quarter

Month	Process Water Discharge BOD	Process Water Discharge TSS	Treated Process Water BOD	Treated Process Water TSS
	(mg/l)		(mg/l)	
1	2,475	1,775	1.85	1.85
2	2,400	1,690	3.07	4.26
3	2,880	1,920	2.56	4.36

Hatfield Uses of Renovated Process Water

Current uses of renovated process water include the following uses: dehairing machine, inedible water flume system, hog pen subfloor flush, and casing striping and flushing. These uses total about 300,000 gallons per day or 46 gallons per hog. Other uses that are non-product contact include use in cooling towers and for boiler feed. These uses total as much as 150,000 gallons per day and have been discontinued due to corrosion concerns caused by the chlorides in the renovated water. An additional use being studied would be to use the renovated water for cleaning and sanitation operations. However, the total solids need to be reduced so that the detergents can work properly. Therefore, a reverse osmosis system is being studied to further treat the water before reuse for these three purposes.

SOLIDS HANDLING

In order to obtain effluent of the desired quality, large volumes of organic waste are removed from the water in the form of solids. The first removal process takes place through two dissolved air floatation units (DAF), which usually generates approximately 35,000 gallons per day of 5 to 6% solids content. The second process of biological treatment produces approximately 20,000 gallons per day of 1 to 2% solids content. Both of these solids are combined and then receive treatment in a belt press operation. Prior to installation of a belt press, Hatfield land applied these liquid solids on land located adjacent to the plant. As more and more solids were being generated, storage and diminishing fields prohibited any additional volume to be applied. In handling the 55,000 gallons of solids in the belt press operation, Hatfield was generating approximately 24 tons of 25 to 30% solids per day; producing approximately six loads of material per week. This material had been land applied adjacent to the plant or hauled to our farm, which is located about 360 miles round trip from the plant. This operation was most economical, but again the increasing volume of material soon limited the application rate allowed for our permitted fields. Therefore, several alternatives were evaluated: landfill, incineration, permit more acres, compost or drying.

Landfill and incineration were not considered because of the initial cost evaluation. Permitting more fields was considered, but in looking at the new Pennsylvania Waste Regulations, Hatfield management felt that this would be too costly and restrictive for us. Due to the consistent quality in nutrient value of our material, it was concluded that the material could be used for other applications which if further processed could also result in volume reduction. Two processes evaluated at this point were composting and heat drying. Composting did not meet management's goals to minimize material handling, utilize available space, and reduce volume, therefore the management team did not select it.

Heat drying was then considered. Some of the advantages identified included volume or weight reduction, more stable product to handle due to low moisture content, pathogen kill due to the temperature of the drying process, and the possibility of a marketable product as either fertilizer or animal feed-supplement. The drying process has now been in operation for over two years, and all of the anticipated goals of the project have been achieved. First, there were no capital expenditures necessary for building improvement. Second, fuel requirements were not as high as expected due to the capability of being able to dry the material to 10% moisture at a temperature of 175 degrees rather than 225 degrees as originally thought. Third, trucking was reduced from six loads per week to two loads per week at a savings of $100,000 per year. Fourth, the dried material is far superior to handle and store, thus allowing for longer storage times and smaller storage areas. Fifth, we have been granted a beneficial use approval from DER for various uses of this material. Sixth, Hatfield is now able to pursue and research the idea of using this material as a feed-stock, a feed-supplement, or a fertilizer for retail sales. In conclusion, there have been many cost savings realized by this project, plus a dollar return that can be applied to the capital cost of the dryer. There have also been many other advantages acquired by this project that cannot be immediately evaluated by actual dollars and cents. Some of these advantages would be to utilize trucking equipment and personnel in other operations of our plant, longer operational life of our hauling and spreading equipment, future capacity to handle more solids without having to hire additional personnel or purchase new equipment. Although this operation has been very successful for Hatfield, it may not be the best choice for other companies. Each company must examine their long-term goals and not just consider short-term intentions. The company should determine what their capabilities are as an individual company in order to acquire a successful major project, such as solids handling through heat drying. However, the ability to properly dispose of recovered solids is a key factor in enabling water reuse.

SIGNIFICANCE

The potential magnitude of savings that can accrue is evidenced when one reviews the potential savings of water reuse. For Hatfield, current costs for water and sewer are $3 per 1,000 gallons for each. In addition to the sewer charge, there is a load charge of $0.75 for each pound of BOD_5 and TSS (and also FOG, phosphorous, and nitrogen but they are not included in this analysis). The potential economic impact of introducing this water reconditioning treatment into the Hatfield plant can be summarized as follows. Using the information provided in this paper, we find an annual savings potential exceeding $5,000,000 . The plant is using 300,000 gallons per day of renovated process water. This would annually save 75 million gallons of water use and sewer discharge valued at approximately $450,00 (250 days, $6/1000 gallons). Tertiary treatment is necessary to prepare the process water for reuse. The plant's effluent discharge is reduced by approximately 3,800,000 pounds of BOD_5 and 2,600,000 pounds of total suspended solids per year. These reductions in waste loads save approximately $2,800,000 per year on BOD_5 and $1,900,000 on TSS surcharges that would be levied by the POTW. Furthermore, the recovered solids are cooked and would be valued at about $10,000 if utilized. Finally, significant energy savings in heating costs of approximately $50,000 per year might be realized through these recycling efforts. Thus, a total annual savings of around $5,210,000, less operating costs and capital investments, can be projected. Based on the total costs of the equipment reported in this study, a cost of $5,000,000 was determined. Operating and maintenance costs total about $525,000 per year. Amortization and interest costs approximate $700,000 per year. Thus, the total annual costs are about $1,225,000. The savings less the costs would result in an equipment payback of about fifteen months. However, since Hatfield is the first plant to attempt the reuse of renovated process water, the management suggests that about $2,000,000 has been spent over the last five or so years on research, testing, and other costs such as engineering and legal fees.

In addition to the use of 46 gallons per hog of renovated water, the management team has demonstrated the value of water conservation and pollution prevention. Past experience in other food plants indicates a 50 percent reduction in water use and waste load is possible with concerted action. For Hatfield, the estimated savings are 75 gallons of water use saved per pig (33% reduction) with a reduction in waste load of approximately 40 percent. The annual benefits of these activities would be a 122 million gallon reduction in water use and sewer discharge and a reduction in waste load of some 3,000,000 pounds of BOD_5. The annual benefit to Hatfield is some $731,250 for water and $3,865,000 for waste load. Management estimates that annual costs to achieve these reductions are less than $ 100,000 per year for labor, testing, valves, pressure regulators and increased maintenance. One should note that the savings are greater and the costs less than for the use of renovated process water. Also, the capital and operating costs for the renovated water system were reduced--perhaps as much as 40 percent because of the water conservation and pollution prevention activities that preceeded the renovated process water reuse.

The total savings of $5.19 per pig is significant. However, the combination of water conservation, pollution prevention and renovated water reuse had an even more significant result. Hatfield has been able to expand their production from 3,000 to 6,500 pigs per day (116 percent) even when no additional water was available and there was no additional wastewater discharge capability.

POSTER

PRESENTATIONS

CONVERSION OF POULTRY WASTE PRODUCTS TO VALUE-ADDED UTILIZABLE PRODUCTS. THE ANIMAL AND POULTRY WASTE MANAGEMENT CENTER AT NORTH CAROLINA STATE UNIVERSITY

C.M. (Mike) Williams
Senior Researcher/Director
North Carolina State University
Box 7608
Raleigh, NC 27695-7608

Food-animal related agribusiness in the United States has for several years accounted for annual revenues exceeding $80 billion. In North Carolina, the poultry industry represents a critical component of agribusiness accounting for approximately $2 billion, or nearly one-third, of the state's farm-gate income in 1993. Nationally, the poultry industry has grown tremendously during the past two decades, and is expected to continue to grow at a rapid rate in coming years. However, the size and magnitude of the poultry, as well as other food-animal industries, results in the production of tremendous quantities of manures and litters, hatchery by-products, feathers and hair, animal mortalities, processing offal and processing waters containing environmental compounds of regulatory concern. Under certain conditions, these by-products can potentially result in odor problems and the pollution of ground and surface waters by inorganic chemicals and pathogens. Environmental concern has resulted in certain federal, state, and local regulatory agencies establishing requirements that waste minimization, and on-site waste recovery and recycling replace land application as the predominant method of waste disposal. Considering the current regulatory focus on agriculture, there is little doubt that the future growth and economic stability of the agricultural food-animal industries will be impacted by their waste management practices. It is logical to anticipate that the long term success of many food-animal industries, including poultry enterprises, will be dependent upon the development of technologies for improved procedures for converting manures, litters, and processing effluents into aesthetically acceptable and economically valuable co-products for the industry.

ANIMAL AND POULTRY WASTE MANAGEMENT - AN OVERVIEW

An overview of current waste management practices utilized by the poultry and other agricultural food-animal industries illustrates the need for alternative waste management technologies. Most manures and litters are currently being applied either in the raw form or as compost to crop and pasture land in the areas where they are being produced. In some cases, concentrated animal units now produce more nutrients than can possibly be utilized by the crops being grown in the local area. Over application of such materials can result in the buildup of nitrates, phosphates, other chemicals and pathogens which hold the potential for polluting ground and/or surface waters. In other cases, manure is collected in lagoons where naturally occurring bacteria, primarily anaerobic species, are used to break down and reduce the amount of waste produced. The liquid from these lagoons is often pumped onto nearby land for potential fertilizer value.

Most hatchery by-products (shells and unhatched eggs) and animal mortalities (especially for poultry and young swine) are currently being buried in pits or are being placed in sanitary landfills. Both practices are likely to be banned in the near future, at least in areas with certain soil types and/or high water tables, so alternatives must be developed to manage and recycle these potentially valuable by-products. Over the past few years, a number of poultry enterprises have begun utilizing the natural biological process of composting to handle their animal mortalities. Mortality composting utilizes a mixture of the dead animals, manure and materials such as straw, sawdust, leaves, grass, corn stover, peanut hulls *etc.*, to provide the carbon and nitrogen needed to allow the bacteria to grow, utilize and break down the animal carcasses. This process provides a good, relatively low-cost alternative for disposing of animal mortalities in an environmentally safe manner, but still results in a product that must be land applied. Carcasses from large animals (beef, dairy, swine, horses, *etc.*) have for many years been rendered and returned to the animal food chain, but due to the small amount of mortality which generally occurs on a daily basis on poultry operations, it has not generally been considered economically feasible for those operations to transport their mortalities to the renderer. Thus, alternative systems need to be developed and demonstrated which will allow on-farm preservation and storage of the preserved carcasses so that larger quantities can be collected and transported to rendering, drying and/or extrusion facilities for conversion into animal feed-grade meals.

Offal from food-animal processing plants has for many years been sold to rendering plants for conversion into feed-grade meat, bone and blood meals. Feathers, another major by-product of poultry processing plants, have been hydrolyzed and converted into feed-grade feather meals. A number of what would appear to be economically viable and better alternatives such as acid fermentation, fluidized bed drying, extrusion, and treatment with newly developed enzymes, have been introduced over the past few years, but these alternatives need to be scaled up and possibly modified so they can be demonstrated to be economically feasible and viable, if they are to become adopted by the animal industries.

Tremendous amounts of water (500,000 to 1 million gallons/plant/day are not uncommon) are used in food-animal processing plants. The waste water from these plants must be treated and purified before being released. Such waste waters contain large quantities of blood, fat and protein; flocculants are currently used to create Dissolved Air Flotation (DAF) sludge to remove these materials. The DAF sludge is extremely difficult to deal with, has little nutritive value, and is often press dried and land applied. New improved, economically-viable methods for separating these materials from processing waste waters must be developed to allow better purification and recovery of the potentially valuable nutrients contained in these waste waters.

The Animal And Poultry Waste Management Center Concept

Numerous alternative processing procedures for food-animal by-products have been proposed by researchers at many institutions in the U.S. and abroad. However, most such alternatives have not been tested beyond the laboratory on a commercial or full scale by the investigators conducting waste management research and extension work due to the lack of infrastructure to do so. The College of Agriculture and Life Science (CALS) at North Carolina State University (NCSU) has targeted agricultural waste management as one of its major research and extension objectives. As part of this effort, an Animal and Poultry Waste Management (A&PWM) Center is being established within CALS. The Animal and Poultry Waste Management Center facilities are to be housed on approximately 5 acres at the North Carolina State University's Agricultural Field Laboratory, located south of the NCSU Campus on Lake Wheeler Road. Two buildings (a 70' X 100' waste processing equipment building and a 36' X 140' composting building) will house the equipment necessary for research, development, and demonstration of advanced waste management technologies. Capital waste conversion equipment available for research utilization includes extruders, a fluidized bed dryer, cooler, roaster, mixer, screw press, and pellet mill. In addition, NCSU's poultry, swine and cattle research units, located on adjacent property, will supplement the Animal and Poultry Waste Management Center facilities. These units are equipped with grow out facilities and standard feed mill equipment such as ribbon mixers, pellet mills, scales, bagging equipment, and meat grinders. Collectively, these facilities will provide the infrastructure for the continued evaluation of innovative alternatives for animal waste management.

The A&PWM Center, however, is not a facility as much as it is an organizational concept. In order to efficiently and effectively address the waste management requirements of the food-animal industries, a broadbased and interdisciplinary participation and input into the A&PWM Center activities is needed. The A&PWM Center has, therefore, established an operational structure in which NCSU, industry, commodity groups, other universities and government agencies may form a partnership to address the agricultural food-animal waste management research area.

<u>A&PWM Center Objectives</u>: The A&PWM Center will be addressing all aspects of food animal waste management from manures and litters, to hatchery wastes, processing wastes, etc. The primary goal will be to convert food-animal industry by-products, which have normally been considered wastes, into value-added products. The specific objectives for the A&PWM Center are:

1. To provide a modern facility and associated equipment (*i.e.*, the infrastructure) for carrying out research and extension educational activities on the management and utilization of food animal waste products; and, for the development of economically and environmentally acceptable procedures for conversion of these wastes into value added products for the food producing animal industries. Once developed, many of these procedures will undoubtedly be adopted by the food-animal industries nationwide and around the world.

2. To provide personnel to operate the facility and its equipment on a daily basis and to work with the faculty and industry groups in carrying out the research and extension educational activities.

3. To provide the infrastructure which will allow participating scientists to be successfully competitive for individual and multi-disciplinary research funding on a national basis in the waste management arena.

4. To provide the national and world food animal-producing industries with economically feasible and safe alternatives for handling and recycling by-products produced by these industries in the course of food production.

5. To facilitate in-service training in new technologies for waste management for extension agents, agricultural agencies, waste management system operators, agribusiness, and other technology-user groups.

It is anticipated that this overall project will result, in the long term, in the development of new and innovative environmental resource technologies. The approach is multidisciplinary and will include not only research and development but a broad and varied education and training program. It is anticipated that this animal and poultry waste management program may become a national and international model for the future training of agricultural waste management scientists in the discipline of waste processing and utilization.

REDUCING PHOSPHORUS RUNOFF FROM FIELD-APPLIED POULTRY LITTER USING ALUM AND FERROUS SULFATE

B.R. Shreve, P.A. Moore, Jr., T.C. Daniel, and D.R. Edwards
Graduate Assistant, Soil Chemist, Professor,
and Associate Professor
University of Arkansas and USDA/ARS
Fayetteville, AR 72701

In 1992, over one billion broilers were produced in Arkansas. In turn, these birds produced vast quantities of manure, which typically is utilized as fertilizer on western Arkansas pastures. Land application rates of litter, composed of manure and bedding materials, are based on meeting the nitrogen (N) requirement of crops. These recommendations do not consider other factors such as phosphorus (P) content of litter, and litter application rates typically supply P in excess of crop demands. Although excess P does not have detrimental effects on land to which it is applied, it can adversely affect surface waters if it moves off-site via runoff or erosion. Vollenweider (1975) has documented the relationship of total phosphorus (TP) concentration of lake water to eutrophication, and P has been identified as the nutrient most often limiting phytoplankton production in lakes (Schindler, 1977).

Edwards and Daniel (1993) reported that with surface-applied litter 2.2 to 7.3% of total P applied was lost in runoff, with 80% or more of P in runoff in the dissolved form. The importance of manure as a source of P to surface waters was demonstrated by Duda and Finan (1983), who report up to 50-fold increases in TP runoff from watersheds with high livestock populations compared to mostly forested watersheds.

To minimize runoff losses of manure P while still supplying crops with adequate N, the available nutrient content of litter should more closely match plant requirements. Increasing N availability or conversely decreasing P availability could accomplish this. Most P in runoff from pastures receiving poultry litter is soluble, therefore converting P to less-soluble or less-available forms would reduce the potential for P losses in runoff. Moore and

Miller (1994) report that several chemical amendments showed potential for converting P to less-soluble forms, but recognized that further research was required to determine detrimental and/or beneficial aspects of chemical amendments to poultry litter. Based on that preliminary work, a study was established to evaluate the effects of alum ($Al_2(SO_4)_3 \cdot 16H_2O$) and ferrous sulfate ($FeSO_4 \cdot 7H_2O$) on P runoff from field-applied poultry litter and on total fescue forage yield and quality from fields receiving amended litter.

MATERIALS AND METHODS

Litter alone and in combination with alum or ferrous sulfate (1:5 amendment:litter) was broadcast applied at 11.2 Mg ha^{-1} to small plots. An untreated control was included. Treatments were arranged in a randomized complete block design with three replications. Rainfall simulators (Edwards and Daniel, 1993) produced three runoff events at 2, 9, and 16 d after litter application. Runoff was collected and analyzed for soluble reactive phosphorus (SRP), total phosphorus (TP), ammonium (NH_4-N), nitrate (NO_3-N), and total nitrogen (TN). Total time of runoff and volume of runoff collected were recorded, and total runoff volume was calculated for use in determining TP loads leaving the plots. Plants were harvested, yields were determined, and tissue was analyzed for TN, TP, and metals. All analyses were made using standard methods. Flow-weighted average concentrations of runoff constituents were used in statistical analyses of the data. Where significant treatment effects were indicated ($p<0.05$), means were separated using Fisher's LSD.

RESULTS AND DISCUSSION

Runoff P and N

Soluble reactive P concentrations in runoff water are presented in Fig. 1. Alum amendment of poultry litter resulted in an 87% reduction in SRP concentrations compared to litter alone for the first runoff event and a 63% reduction for the second runoff event. Ferrous sulfate amendment of poultry litter decreased SRP concentrations by 77% and 48% for the first and second runoff events, respectively, compared to litter alone.

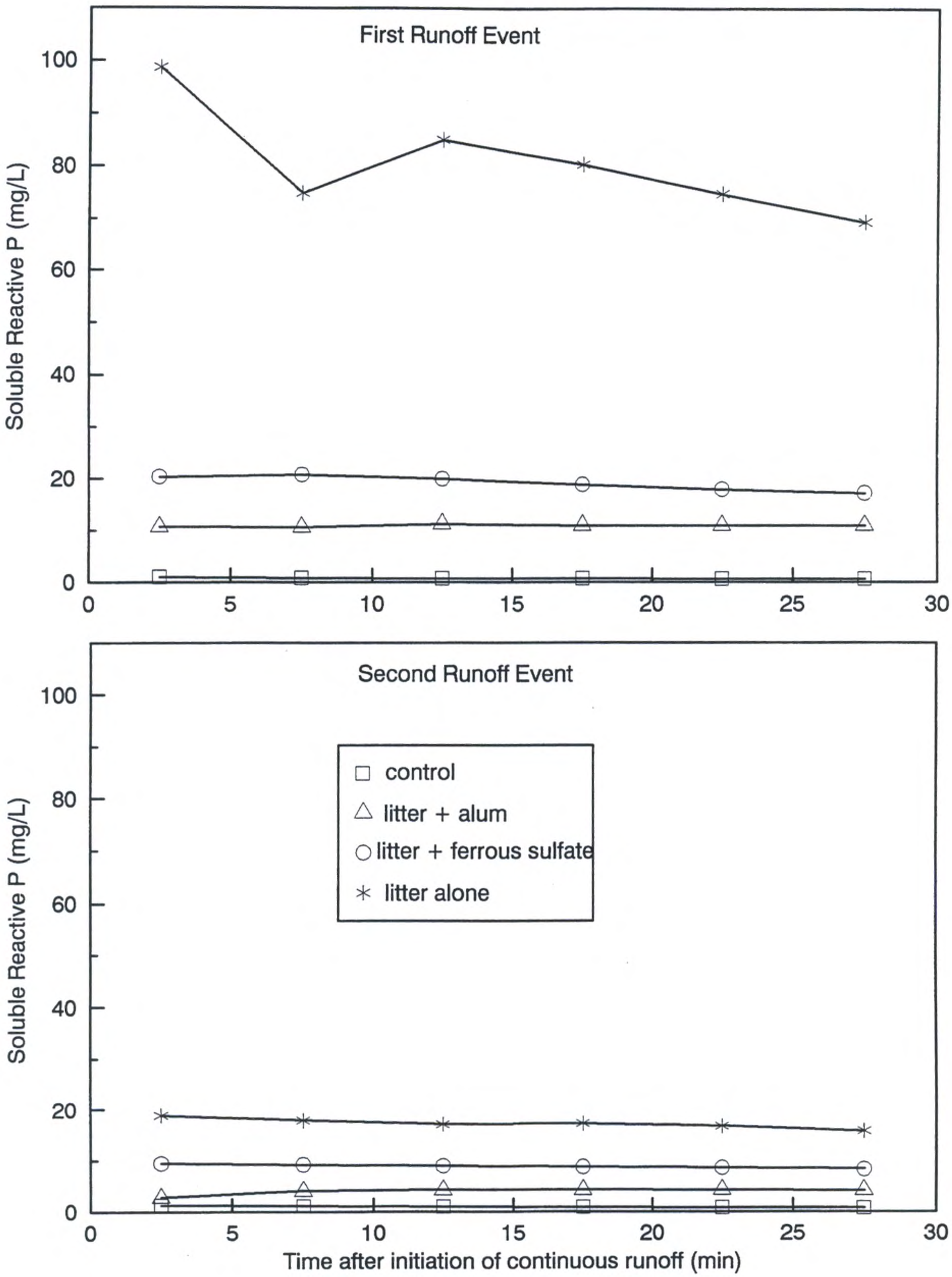


Figure 1. Litter amendment effects on runoff SRP.

In all three runoff events, both alum and ferrous sulfate produced significant decreases in runoff SRP and TP in comparison to litter alone. Litter alone resulted in runoff SRP concentrations of 83, 17, and 8 mg L^{-1} for the three runoff events, whereas control plots had SRP concentrations in runoff of 1, 1, and 2 mg L^{-1}. Runoff concentrations of SRP from amended litter were not different from the control (α=0.05). Total P levels followed a similar trend. When runoff concentrations are converted to mass loads, significant decreases were obtained in P load with chemical amendments in the first runoff event only (data not shown).

Concentrations of N in runoff were also influenced by litter amendments. Nitrate-N concentrations were at or below background levels for the first runoff event, therefore no data are presented. In the second and third runoff events, however, NO_3-N concentrations were increased by application of litter over that of the control (1.2 vs. 0.3 mg L^{-1}), and were increased by ferrous sulfate over alum for both events (1.5 vs. 0.6 mg L^{-1}). Litter application increased NH_4-N concentrations for all three runoff events over the control. Litter alone had runoff NH_4-N of 55, 7, and 1 mg L^{-1} for the three runoff events, whereas the control had less than 0.1 mg NH_4-N L^{-1} for all runoff events. Chemical amendments further increased NH_4-N concentrations in the first and third runoff events, whereas only ferrous sulfate amended litter displayed this increase in the second runoff event (data not shown). Total N was also increased by litter application during all three runoff events from 1 mg N L^{-1} in the control up to a maximum of 207 mg L^{-1} . Amending litter with ferrous sulfate increased runoff TN in the first and second runoff events compared to the other treatments, whereas no differences were observed between amended litter and litter alone for the third runoff event (data not shown).

Fescue Yield and Quality

Forage yield and quality were increased by all litter treatments (Table 1). Alum amended litter produced significantly greater yields than all other treatments. This yield response is most likely due to increased available N with this treatment resulting from decreased ammonia volatilization (Moore et al., 1994).

Fescue showed significantly increased concentrations of N and K, and decreased concentrations of Ca and P with litter application. Although tissue concentrations of these two elements decreased with litter application, total uptake of Ca and P was greater due to the much greater yields. Alum amended litter produced significantly greater forage N concentrations than all other treatments (Table 1).

Although statistically significant differences existed between litter treatments, all metals with the exception of K are at tissue concentrations well below those considered to be toxic to livestock (National Academy of Sciences, 1980). For all treatments including the control, K levels were above three percent, which is considered to be the toxic level for ruminants by the National Academy of Sciences (1980). The ratio K/(Ca+Mg) in plant tissue, associated with grass tetany potential, exceeded the commonly accepted threshold value of 2.2 for all treatments including the control (Table 1), indicating the need for careful management of grazing livestock in this area.

Table 1. Effect of poultry litter amendments on mean fescue yield and composition.[a]

Constituent	Litter + alum	Litter + $FeSO_4$	Litter alone	Control	LSD[b]
	($kg\ ha^{-1}$)				
Yield	2358	1974	1847	733	290
	($g\ kg^{-1}$)				
N	27	26	24	17	3
P	6.5	6.1	7.3	9.3	0.9
K	117	116	108	74	8
Ca	5.5	5.0	5.6	6.7	0.5
Mg	3.5	3.6	3.5	3.3	NS[c]
K/(Ca+Mg)	13.0	13.5	11.9	7.4	1.0

[a] Mean concentration of two sampling dates.
[b] α=0.05.
[c] NS = Not significant.

Implications

Runoff concentrations of both N and P were influenced by chemical amendments to litter, indicating that both alum and ferrous sulfate affected the chemistry of these litter constituents. Increased available N and decreased soluble P make treated litter more valuable as a fertilizer, which may make transportation of litter over long distances more economically feasible. In areas where limited land is available for application of litter, this can become an important consideration.

Observed decreases in SRP and TP runoff concentrations from soils receiving chemically treated litter probably result from precipitation and/or adsorption reactions which decrease P solubility in litter. Initial results from an ongoing study indicate that these Al-bound or -precipitated P forms are stable in soils over a wide pH range (4 to 9).

Increased runoff N concentrations from amended litter result from a decrease in ammonia volatilization. The effect of these amendments on NH_3 volatilization and the benefits of lowering NH_3 levels are discussed in detail by Moore et al. (1994). With the increase in N content, some reduction in litter application rates might be expected, while still providing crops with adequate N.

Alum-amended poultry litter dramatically decreased SRP and TP concentrations in runoff, decreased TP loads, and increased forage yield and N concentration. Chemically amending poultry litter with alum shows considerable promise as a management tool for limiting inputs of P to surface waters, for increasing the fertilizer value of litter, and for having potential economic benefits for poultry producers. Thus, alum treatment of poultry litter may become part of a new best management practice for areas with surface waters that are susceptible to eutrophication.

REFERENCES

Duda, A.M. and D.S. Finan. 1983. Influence of livestock on nonpoint source nutrient levels of streams. Trans. ASAE 26:1710-1716.

Edwards, D.R. and T.C. Daniel. 1993. Effects of poultry litter application rate and rainfall intensity on quality of runoff from fescuegrass plots. J. Environ. Qual. 22:361-365.

Moore, P.A., Jr., and D.M. Miller. 1994. Decreasing phosphorus solubility in poultry litter with aluminum, calcium, and iron amendments. J. Environ. Qual. 23:325-330.

Moore, P.A., Jr., T.C. Daniel, D.R. Edwards, D.M. Miller, and B.R. Shreve. 1994. Effect of chemical amendments on ammonia volatilization from poultry litter. In 1994 Proceedings National Poultry Waste Management Symposium (this issue).

National Academy of Sciences. 1980. Mineral tolerance of domestic animals. National Academy Press, Washington, D.C.

Schindler, D.W. 1977. The evolution of phosphorus limitation in lakes. Science 195:260-262.

Vollenweider, R.A. 1975. Input-output models with special reference to the phosphorus loading concept in limnology. Schweiz. Z. Hydrol. 37(1):53-84.

EFFECT OF CHEMICAL AMENDMENTS ON AMMONIA VOLATILIZATION FROM POULTRY LITTER

P.A. Moore, Jr., Soil Chemist, USDA/ARS, Poultry Waste Lab.,
T.C. Daniel, Professor, Agronomy Dept, Univ. of Ark.
D.R. Edwards, Assoc. Prof., Agri. Eng. Dept., Univ. of Ark.
D.M. Miller, Assoc. Prof., Agronomy Dept., Univ. of Ark.
B.R. Shreve, Grad. Ass., Agronomy Dept., Univ. of Ark.
Plant Sciences 115, University of Arkansas
Fayetteville, AR 72701

For over 30 years, researchers have known that ammonia (NH_3) levels build up in poultry rearing facilities and this buildup adversely affects chickens. Valentine (1964) documented NH_3 levels in the 60 to 70 ppm range in the atmosphere of poultry houses. High NH_3 levels in poultry houses are more common in the winter since the houses are closed this time of the year. In Europe, COSSH (Control of Substances Hazardous to Health) has set the limit of human exposure to NH_3 at 25 ppm for an eight hour day and 35 ppm for a 10 minute exposure (Williams, 1992).

High NH_3 levels in poultry houses have been shown to cause damage to the respiratory tract, increased susceptibility to Newcastle disease, increased incidence of airsaculitis, impaired immunosuppresion, decreased growth rates, decreased egg production, reduced feed efficiency and cause keratoconjunctivitis in poultry (Carlile, 1984).

Carlile (1984) suggested that 25 ppm NH_3 should not be exceeded in poultry houses. Attempts to inhibit NH_3 volatilization from poultry litter were first reported in the 1950's. Since that time many different chemicals have been tested for their effectiveness to inhibit NH_3 release from poultry litter. These compounds include acetic acid, antibiotics, ferrous sulfate, gypsum, hydrated lime, limestone, paraformaldehyde, phosphoric acid, propionic acid, superphosphate, yucca plant extracts (saponin), and zeolites like clinoptilolite.

The objectives of this research were to determine the effect of various amendments on (1) NH_3 volatilization from litter, and (2) nitrogen and phosphorus transformations in litter.

LABORATORY STUDIES ON AMMONIA VOLATILIZATION

Experiment One

Eleven treatments were utilized in each of two laboratory studies on ammonia volatilization. Ammonia-free air was passed through air-tight containers containing poultry litter and any NH_3 volatilized from the litter was trapped in boric acid solutions, which were titrated daily for NH_4 content. The study was carried out for 42 days.

The results of the first laboratory study indicated that alum and ferrous sulfate reduced NH_3 volatilization from litter by 99 and 58%, respectively (Figure 1). Applications of MLT (Multi-Purpose Litter Treatment) actually increased volatilization. The recommended rate of MLT resulted in 31% more N loss via volatilization than the controls. At two times the recommended rate, volatilization was 15% higher than the controls. These results are not surprising since the pH of MLT and water is around 10. Increases in litter pH shift the NH_3/NH_4 equilibrium towards NH_3, resulting in higher volatilization. Other compounds which did not reduce volatilization include $Ca(OH)_2$, fly ash, acid mine soil, and waste products from aluminum refineries.

In figure 2, the total N content of the litter after 42 days of incubation is plotted as a function of the cumulative NH_3 volatilization for the various treatments. Treatments with higher volatilization had lower total N contents at the end of the study, as would be expected. The total N content of the 200 g alum kg^{-1} treatment was 41.5 g N kg^{-1}. This was somewhat higher than the original N content (38.5 g N kg^{-1}). If the amount of alum present had been taken into account, the N content would be 51.9 g N kg^{-1}. Higher total N contents are due to losses in C via CO_2 evolution from microbial decomposition. The controls contained 26.1 g N kg^{-1} at the conclusion of the study. Therefore, the addition of alum at the higher rate resulted in a doubling of the N content in the litter, which would greatly increase the value of poultry litter as a fertilizer source.

The rate of NH_3 volatilization is dependent on pH, moisture content, wind speed, ammonium concentration and temperature. Volatilization increases with increases in any of these variables. The pH of litter is very important because it determines the ratio of NH_3/NH_4. As pH increases, this ratio increases, causing volatilization to increase and vice versa. Therefore, acid forming compounds, like alum and ferrous sulfate, reduce volatilization, whereas basic compounds like MLT (which has a pH of 10) increase volatilization. Although increased ventilation will solve most of the health problems associated with high NH_3 levels in poultry houses, it is impractical during winter months, due to energy costs.

Experiment Two

In order to determine the relative effectiveness of the products currently being sold as NH_3 volatilization inhibitors, a second lab study was conducted (Figure 3). Ammonia volatilization from litter treated with MLT was 8% higher than the controls. These results confirm those found in experiment 1 and indicate that this product, which is currently being sold in several states, increases rather than decreases NH_3 volatilization. De-odorase, a product made from yucca plants, also increased volatilization (9% more N loss than controls). The only two commercial products that appeared to work at all were Ammonia Hold and PLT, which reduced N losses by 29 and 23%, respectively, compared to the controls. However, NH_3 volatilization was much lower with ferrous sulfate and alum, which resulted in 65 and 85% less N loss, respectively. These data indicate that these two treatments are far better than what is currently commercially available.

It should be noted that alum and ferrous sulfate would be more desirable than Ammonia Hold and PLT from an environmental point of view since they would immobilize soluble P in the litter. On the other hand, phosphoric acid is used to produce Ammonia Hold. This would result in higher P loading to land, resulting in higher P runoff. PLT is composed of $NaHSO_4$, which reduces litter pH and dissolves calcium phosphates, without providing a P precipitating agent, like Al or Fe.

ENVIRONMENTAL CHAMBER STUDY - EFFECT OF LITTER AMENDMENTS ON AMMONIA VOLATILIZATION AND BROILER PRODUCTION

This study was conducted in 12 ventilation controlled animal rearing chambers with 120 male broilers per chamber. The equivalent of 100 kg of dry litter was weighed out into each chamber. Amendments were then mixed into the litter prior to each growout. The amendments were: (1) no amendment (control), (2) alum, (3) $FeSO_4.7H_2O$, and (4) liquid $FeCl_3$. There were three replications per treatment in a completely randomized design. Ammonia measurements were made in each chamber biweekly. Feed and water was provided ad libitum. Commercial medicated broiler starter feed was fed until day 21, at which time commercial broiler grower feed was provided. Group bird weight and feed weight for each chamber was determined weekly.

Ammonia concentrations in the chambers containing litter treated with chemical amendments were much lower than the control chambers (Figure 4). The average NH_3 concentration in the control chambers was 55 and 69 ppm in the first and second growout, respectively. The lowest NH_3 levels were observed in the chambers containing alum-treated litter, which averaged 23 and 25 ppm NH_3 for the first and second growout, respectively. As indicated in the introduction, 25 ppm is considered a "safe" NH_3 concentration, with respect to poultry production, whereas levels above 50 ppm often result in decreased growth, poor feed conversion, and disease problems. The NH_3 in the chambers containing ferric chloride and ferrous sulfate treated litter were intermediate between the controls and the chambers containing alum-treated litter.

Litter pH was significantly lower by all of the chemical amendments compared to the controls. The average pH of the control litter was 8.09 and 8.23, respectively, for the first and second growout. These values are much higher than those found for the alum treated (6.82 and 6.63), ferrous sulfate (7.32 and 7.11), and ferric chloride-treated litter (7.17 and 7.33). Atmospheric NH_3 levels were highly correlated to litter pH, with the lowest values observed under the most acidic conditions.

Two other litter characteristics affected by the amendments were water soluble phosphate and ammonium (data not shown). Ammonium was higher, as would be expected when NH_3 is inhibited. Water soluble phosphate was significantly lower in litter which had been amended with the aluminum and iron treatments. Reductions in water soluble phosphate are highly desireable from an environmental view. Phosphorus runoff from litter-amended fields is considered to be the biggest water quality problem associated with poultry production in the United States. Treating litter with alum greatly reduces phosphorus solubility in litter (Moore and Miller, 1994), which in turn decreases phosphorus runoff from fields fertilized with litter (Shreve et al., 1994).

REFERENCES

Carlile, F.S. 1984. Ammonia in poultry houses: A literature review. World's Poultry Science Journal 40:99-113.

Moore, P.A., Jr. and D.M. Miller. 1994. Decreasing phosphorus solubility in poultry litter with aluminum, calcium and iron amendments. J. Environ. Qual. 23:325-330.

Shreve, B.R., P.A. Moore, Jr., T.C. Daniel, and D.R. Edwards. 1994. Reducing phosphorus runoff from field-applied poultry litter using alum and ferrous sulfate. In 1994 Proceedings National Poultry Waste Management Symposium (this issue).

Valentine, H. 1964. A study of the effect of different ventilation rates on the ammonia concentrations in the atmosphere of broiler houses. Br. Poultry Sci. 5:149-159.

Williams, P.E.V. 1992. Socio Constraints on poultry production - Addressing environmental and consumer concerns. pp. 14-29 In 1992 Proc. Ark. Nutrition Conference, Fayetteville, AR.

POULTRY WASTE UTILIZATION ISSUES: A FOCUS ON THE DELMARVA PENINSULA[1]

C. A. Narrod
Center for Energy and the Environment
University of Pennsylvania, Meyerson Hall
210 S. 34th Street
Philadelphia, PA 19104

R. D. Reynnells
NPL-Poultry Science, USDA/ES, Room 3334-S
Washington, DC 20250-0911

H. Wells
US EPA, (MC7409), 401 M Street, SW
Washington, DC 20460

The disposal of poultry and other livestock waste is often a negative externality to society. The poultry industry has three potential externalities which may affect water quality: production, processing, and, supply of inputs. Manure and litter are positive externalities and are valuable sources of nitrogen, phosphorous and organic material. However, due to the nature of some soils and some management practices, saturation with nutrients may be a problem, and thus becomes a negative externality when excess nitrogen or phosphorous leaches into the groundwater or contaminates surface water. A second externality is the by-products from processing which, if discharged untreated into the water may cause a major point source of water pollution. A third externality is the release of ammonia or odors from manure into the air, causing air pollution. These wastes are considered a major non-point source of pollution and in some areas are causing a growing environmental threat. The potential environmental risks due to disposal of these wastes are magnified as a result of the dense confinement of poultry and livestock and the decreasing amount of land available for waste disposal. This resource is a valuable source of nitrogen and phosphorous; however, due to the

[1]Parts of this project was funded separately by USEPA and USDA-Extension Service. For a more detailed discussion of these issues see Narrod et al., 1993.

nature of some soils, saturation with these nutrients may be a problem.

This situation is of particular concern in the Delmarva Peninsula where the industry is highly concentrated in an area of 16,000 km^2, much of which is marginal land that may not be able to assimilate the waste produced from this level of production. Currently the Delmarva industry has an annual production of about 517 million chickens, with an average of 50,000 broilers per growout, producing about 5 tons of manure per 1000 chickens, per year. Carr and Brodie (1992) estimated the annual by-product of production is 646,250 tons of poultry litter, 24,816 tons of dead birds, 12,480 tons of hatchery waste, and 15,510,000 gallons of DAF skimmings.

Currently on Delmarva, best management practices (BMP) and nutrient management plans (NMP) are used to correctly land apply manure. Cost-share money is available to aid farmers in their manure management through various state and federal financial assistance programs (e.g., ASCS, SCS, and revolving funds). Farmers have NMP's as part of their soil conservation and water quality plan, and are required to have NMP's to obtain cost-share money for manure storage sheds and dead bird composters. Maryland has developed a program to certify individuals to prepare these plans. Currently many officials and industry representatives believe there is no excess of manure in Delmarva, however, these evaluations are based on nitrogen, not phosphorus, standards.

INDUSTRY SURVEY

In order to better understand the potential impacts of pollution prevention regulations, a survey was sent to the poultry industry in the summer of 1993, which solicited their views on the current roles of the poultry industry in waste management. Respondents indicated that responsibility for manure belonged to the grower, but if manure is sold or given away, the individual using it is responsible. Also, indicated was that poultry are owned by the company from the breeder flock through the growout stage, but if the bird dies, usually the grower has the disposal responsibility. Processing plant sludge was shown to be the responsibility of the company, and discharge from these processing facilities is recognized as a potential point source of pollution. Also indicated was that if the question of manure ownership were ever challenged in court, the integrated company might be deemed responsible for the waste because the integrated company supplies related inputs. Some respondents felt that such a decision could harm growers if it resulted in more restrictions written into the contracts or in a move toward a totally company-owned growout unit. Many of the companies are aware of the environmental problems associated with poultry production and some are actively working with the growers to find alternative methods of disposing of dead birds and animal manure in less environmentally hazardous ways. Many respondents were unclear of the ramifications of the Clean Water Act and the Coastal Zone Management Act on the industry.

POLICY IMPLICATIONS

Part of the problem in choosing an effective and efficient policy that will correct the environmental problems associated with the poultry industry is determining who is responsible for the pollution. When property rights are not well defined, Coase (1960) has suggested that the agents can negotiate among themselves for appropriate compensation for incidental services. The agents in this situation would be the growers, vertically-integrated firms, and society who should work together at alleviating the environmental problems associated with the waste. It is important for these agents to cooperate because the inability to define responsibilities, and the resulting failure to met societal goals could in the future result in having the government decide the issue of ownership of, or responsibility for, all by-products of production that may cause pollution. If a government decides it is necessary to intervene, it then has to decide how much protection is necessary, who pays, and if the amount will allow for tradeoffs. Specifically, there has to be a decision whether a zero-risk scenario will be pursued or if there is a safe level of pollution. This could result in a trade-off between productivity and water quality. Reductions in productivity could result in price increases for consumers, and adversely affect lower income facilities.

There are three types of policy options that have to be followed in different parts of the world in relationship to water quality: voluntary, command-and-control, and market mechanisms. The voluntary approach relies on getting individuals to adopt environmentally sound practices, which can save society money compared to a program that has enforcement costs. The types of voluntary approaches that have been used in the water quality area are: education, technical assistance, and cost sharing for BMPs. Some voluntary approaches have been successful in Delmarva. The manure clearinghouse system of the Delmarva Poultry Industries, Inc. attempts to move the manure from surplus areas to deficit areas, but it may be under utilized. In the dead bird composter and manure shed areas, the most successful efforts seem due to cost-share programs.

However, the misuse of manure sheds has resulted in a reevaluation of specific structural standards. Part of the problem of a voluntary approach to waste management is the ability to hold individuals accountable and enforce policy. Currently most states are relying on voluntary programs that minimize economic effects. An easier method from a societal viewpoint might be to let the vertically integrated firms be responsible for getting growers to meet environmental restrictions. The problem with this is where several firms compete in a restricted area, no one will want to be the first to bear the expense, and possibly alienate growers. Such a problem is a classic case of the economist's "prisoner's dilemma", and promotes a free-rider situation. To correct this situation the industry would have to agree to follow a collective policy. Unless these voluntary approaches work successfully there will be a move toward instituting other regulations.

A command-and-control approach declares that there is a source-specific pollution problem in which a limit will be set and backed up by the threat of enforcement actions. In the past, most environmental regulations used in the United States has relied on a command-and-control approach. Manufacturing and industries have been the most affected by this type of regulation. This type of regulation, however, has often failed to include the small producer (such as contract growers) and other individuals whose type of discharge was less amenable to this sort of regulation. The water pollution problem in the poultry industry is generated from the improper disposal of manure and/or dead birds at the grower stage of production. It is possible that these small producers will not be able to afford to meet the mandates enforced on them. Those that can't will be forced ultimately to go out of business. This is a particular concern in the poultry industry where most of the production is done by contract growers. It is possible that any policy that regulates the control of manure would ultimately affect the grower because if the company is forced to comply, it will likely write the necessary changes for compliance into grower contracts.

Economic incentives are instruments that influence, rather than dictate, actions and allow businesses and consumers to make their own choices by providing inducements to make reductions in environmental pollution. These policies attempt to correct market failures by adjusting the costs faced by the private decision-makers to reflect the full social costs of their actions. The major advantage of economic incentive is that they allow industries to respond to societal demands and information about scarcity, to be transmitted to various actors through prices and quantities demanded. However, these mechanisms can be restricted by information costs, economies of scale, joint impact goods that effect others (e.g., Prisoner's dilemma, free rider problem), short versus long-term effects, and outcomes that may be "efficient" but socially undesirable. Different types of economic incentives to reduce environmental problems that most relate to the poultry industry, are marketable permits, subsidies/monetary incentives, information disclosure, and taxes.

VALUE-ADDED MARKET OPTIONS

Poultry manure has the potential to be marketed as a commercial or residential fertilizer, animal feeds, methane sources, feedstocks, soil amendments, and numerous other uses. The success of the marketing options depends on the types of crops utilizing the manure, the distance from the farms that needs it, and the willingness of the individual to use the manure as a product. Currently most of the manure from poultry operations, including the Delmarva is directly applied to land. Several states are considering legislation to control waste utilization that are based on phosphate standards. Although manure and litter have many potentially valuable uses, areas with concentrated poultry production may not have adequate cropland and livestock for effective utilization. Therefore, exporting litter from concentrated areas to surrounding areas may be both environmentally and economically beneficial (Bosch and Napit, 1991).

Composting is an alternative way to market poultry litter and make the export of by-products more economically feasible. The composting process is relatively inexpensive but a guaranteed supply of manure, and a suitable market must be available before it will become an attractive alternative (Rynk et al., 1992). The development of a compost market in the Delmarva Peninsula appears feasible and various entrepreneurs are attempting to establish composting, chemical supplementation, and/or pelletizing facilities. Several agencies have applied for special non-point source pollution funding grants to demonstrate the market opportunities for pelletized broiler litter, but have been denied because among other things it would take 2-3 years to show a measured reduction in pollution rates, which exceeds the one year limitation on pollution prevention grants. Perhaps EPA and USDA should be looking more closely at this potential, rather than addressing the need for setting up a central composting facility.

A major obstacle in the marketing of these by-products is the perception of biosecurity risks. Contamination may be direct through dust particles shed from transport vehicles or indirect through disease agents brought back to the farm from central processing facilities or other locations. This concern has been magnified since the Avian Influenza crisis. It will be difficult to address the feasibility of transporting waste off the farm unless there is some actual proof that there is no biosecurity problem with the transport of unprocessed products off farm. Policies promoting the utilization of a central compost facility will be limited unless scientists are able to compensate for, and change people's perceptions of, biosecurity problems based on facts, and policy makers are able to discern the real risks.

WHY THE POULTRY INDUSTRY SHOULD BE CONCERNED

It is recognized that the potential environmental risks due to the disposal of wastes are magnified in Delmarva as the result of the dense confinement practices and the geographical concentration of the poultry industry. Alternatively, having to ship waste from concentrated areas to less concentrated areas requires the promotion of a policy that results in limiting the concentration of all the animal industries. Flock size could be limited to the carrying capacity of the available land base. Such a policy could affect the spatial cost of production. Aho (1989) determined that if plants had to relocate farther apart it would increase costs to nearly one cent per pound for deliveries from the feed mill, processing plant, and hatchery. An increase in the supply band to a distance of 35 miles away from the growout operation would double the spatial costs and increase the costs to $2 million per year. Such an increase in cost would result in increased prices for the consumer.

One purpose of this project was to determine the potential for setting up a central compost facility on Delmarva with the help of government. Based on preliminary numbers in our report it would be possible to assimilate all the manure on the Delmarva Peninsula based on use of a nitrogen standard to apply the manure. If these states choose to turn to a phosphorous standard, it is very likely manure in saturated areas will need to develop a method to get the manure off the peninsula or reduce the concentration of animal units. If so, this would be an additional reason to consider a proactive approach such as composting or processing at centralized facilities. By doing so, the perception of the manure situation could change (with education) from a liability to being viewed as a resource. It is important that attention be paid to this issue now while the industry and producers can still voluntarily change the situation without regulations or changes in consumers attitude about poultry products.

REFERENCES

Aho, P., 1989. Spatial Costs and the Economics of Manure Management. Presented at the Symposium on the Clean Water Act and the Poultry Industries, Washington, D.C.

Bosch, D. and K. Napit, 1992. Economics of transporting poultry litter to achieve more effective use as fertilizer. Journal of Soil and Water Conservation 47:342-346.

Carr, L. and H. Brodie, 1992. Composting Hatchery By-Products and DAF Skimmings. Presented at Midwest Poultry Federation Convention, Minneapolis, Minnesota.

Coase, R., 1960. The Problem of Social Cost. J. of Law and Economics 3:1-44.

Narrod, C., R. Reynnells, and H. Wells, 1993. Potential Options for Poultry Waste Utilization: A Focus on the Delmarva Peninsula. White Paper for USEPA/ESUSDA.

MANURE STORAGE FACILITIES ON ALABAMA POULTRY FARMS

James O. Donald
Department of Agricultural Engineering

John P. Blake
Department of Poultry Science

Franklin H. Wood
Alabama Cooperative Extension Service

Auburn University, AL 36849

Broiler litter production in Alabama has been estimated at nearly two million tons annually. Major uses of broiler litter in Alabama include:

- Fertilizer and soil conditioner for crop and pastureland,
- Soil amendment or potting medium for the nursery, ornamental horticulture, and lawn and garden markets, and
- Feed supplement for beef cattle.

When handled properly, poultry manure is the most valuable of all manures produced by livestock. If broiler litter is properly stored or applied to an actively growing crops, then nutrients are used efficiently and contamination of surface water and groundwater is reduced. On the other hand, if broiler litter is not managed properly after removal from the broiler house, then valuable nutrients can be lost and surface and groundwater contaminated. Following good management practices and guidelines is absolutely essential for ensuring the quality of surface and groundwater.

ESTIMATING BROILER LITTER PRODUCTION

Broiler litter is a combination of bedding material, such as wood shavings, peanut hulls, rice hulls, or recycled paper products with manure. A field test for determining the amount of manure generated on a typical Alabama broiler farm was conducted on the Charles Conner Farm in Marshall County, Alabama. A 4.4 pound broiler was grown in 40 by 500 foot broiler houses. Pine shavings were used as the bedding material at a depth of 2.5 inches. Additional shavings were placed in the brooding area of the broiler house between flocks.

In this field test, a total of eight flocks of broilers were grown on the bedding material during the course of slightly over one year. The amount of litter obtained from a single house was weighed during total clean-out. The amount of litter removed between flocks with a house keeping machine was also accounted for. Following eight consecutive broiler flocks, a total of 502,600 pounds of broiler litter was removed from the house. The average moisture content of the litter was 19.2%. On a dry matter basis, the average values for N, P_2O_5, and K_2O in the litter were 4.2, 4.2, and 2.9%, respectively.

There were a total of 221,160 broilers reared to market weight for eight consecutive flocks. A total of 973,104 pounds of live weight were produced. Based on the amount of live weight, an average of .52 pounds of litter was produced per pound of liveweight (or per pound of meat). Alabama broiler growers have typically used an average value of 0.5 to 0.7 lbs of litter produced per lb. of liveweight as a rule of thumb. The information acquired from this field data confirms this rule of thumb.

Information obtained from this field test can also be useful in sizing litter storage structures. Litter was obtained at various locations throughout the broiler house to determine the bulk density of the litter. Results indicate that poultry litter obtained from this field test, after supporting eight consecutive flocks, weighed 31 pounds per cubic foot based on said conditions. This confirms information that has been reported previously.

TYPES OF MANURE STORAGE

Broiler litter can be stored in a variety of ways. No matter how it is stored, however, it must be protected from prolonged contact with rainwater to retain nutrients and to prevent leaching or runoff. This requires a surface that sheds water. A stockpile of broiler litter left uncovered during the winter can lose up to 80% of its available nitrogen. Nitrogen lost from litter can be varied by runoff water to surface streams or into groundwater sources. A protective surface can be provided by constructing a stockpile of compacted litter, by covering the pile with plastic sheeting, or by providing a permanent roofed structure. Methods of storage in Alabama include:

- Covered stockpile,

- Roofed storage structure.

The key to safe and effective storage should take into consideration the following guidelines:

- Become familiar with soil type and texture in locating manure storage facility.

- Provide a buffer area around storage facility with an appropriate cover crop.

- Place out of public view, when possible, both for aesthetics and odor and fly control.

The ideal system for temporary storage of manure generated by broiler operations is a roofed structure with an earthen or concrete floor (Figure 1). In Alabama, roofed storage structures are becoming more commonplace. The roofed storage structure may be simply a ole barn with an earthen floor and no sides. It may also have walls made of concrete blocks, poured reinforced concrete, or treated wood. Even though structure with wooden walls is cheaper to install, such a structure requires certain precautions. The producer must prevent excess heating by keeping the litter dry and stacking it no higher than five feet against the walls. Spontaneous combustion of damp manure may cause fires in timber structures.

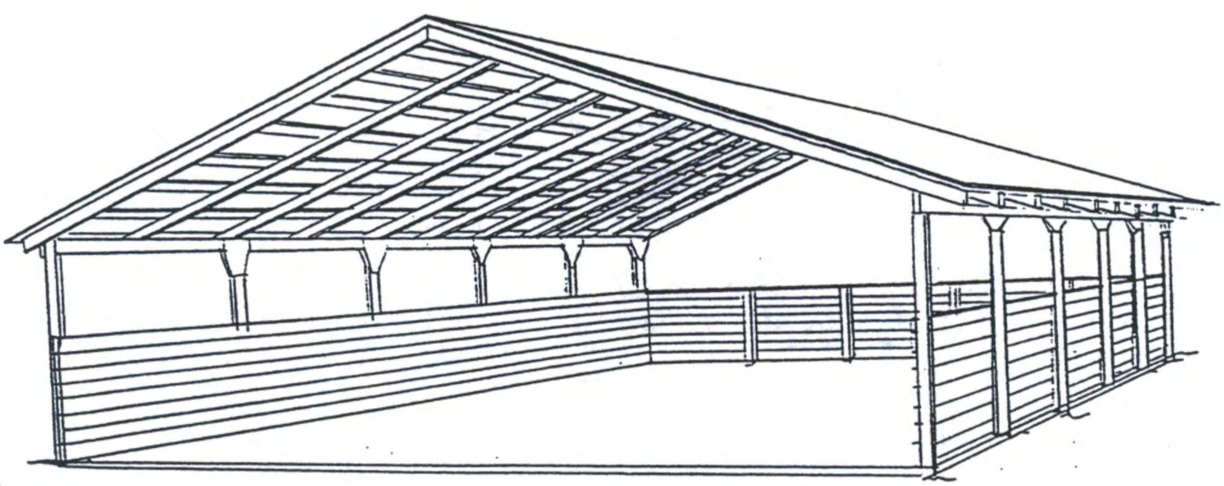


Figure 1. Covered storage structure for broiler litter.

Storage structures in Alabama are typically clear span supported by outside walls or perimeter posts. Interior posts would obstruct loading and unloading of the structure. Wooden posts located within the confines of the litter pile may ignite due to spontaneous combustion. Roof structures must be tall enough to allow manure to be piled an compacted. Often dump height of the truck is the factor governing eave height of the storage structure. Roofs 12 feet or higher may require wall panels and curtain to protect the stored litter from excessive blowing rain.

Large quantities of manure can be stored and kept dry in these structures, promoting easy handling and uniform distribution. Temporary manure storage allows for better utilization of nutrients, either as a fertilizer or as a feed supplement for cattle. Wastes can be applied in split application during the growing season rather than in one heavy application during the clean-out of the poultry houses. This practice increases crop production, helps reduce the potential for nitrate contamination of groundwater, and provides the producer with greater flexibility in management.

Broiler litter is a valuable resource when properly applied. To ensure proper application, consider:

- Apply when least offensive to your neighbors, accounting for time of day and wind direction.
- Do not apply broiler litter in areas that have high potential for runoff.
- Do not apply within 100 feet of river, lake, or stream.

SUMMARY

Establishing a sound Waste Management and Environmental Protection Plan is an important first step for an environmentally responsible poultry operation. The institution of voluntary compliances in Alabama has proven to be successful in ensuring that all the manure produced from a grower's population of birds can be applied at acceptable rates on available land. Construction of over 100 manure storage facilities on Alabama broiler farms has proven to be an environmental investment that allows for proper storage of manure. The ideal system for storage of poultry manures is a roofed structure with an earthen or concrete floor. Quantities of manure can be stored and kept dry in these structures, promoting easy handling and uniform distribution of manure onto pasture or cropland at a time appropriate for the need of manure nutrients. Temporary manure storage allows for better utilization of nutrients, either as a fertilizer or cattle feed supplement.

Manure can be applied in split application during the growing season as opposed to one heavy application during clean-out of the poultry house. This practice increases crop production, reduces the potential for nitrate contamination of groundwater and provides greater flexibility in management. The use of manure storage structures is considered a "best management practice" for the protection of environmental quality.

REFERENCES

Blake, J. P., J. O. Donald, H. D. Harkins, and J. K. Tucker, 1994. Manure storage facilities on Alabama poultry farms. Poultry Sci. 73(1):67.

Payne, V. W. E., and J. O. Donald, 1990. Poultry Waste Management and Environmental Protection Manual. Circular ANR-580 Alabama Cooperative Extension Service, Auburn University, AL.

SMALL-SCALE COMPOSTING OF POULTRY CARCASSES

John P. Blake
Department of Poultry Science

James O. Donald
Department of Agricultural Engineering

Donald E. Conner
Department of Poultry Science

Auburn University, AL 36849

In 1993, Alabama ranked second in the nation in broiler production and produced approximately 900 million broilers. While the industry produces 18 million broilers every week, it generates 800 tons of carcasses weekly, as well. Every broiler production facility must face the reality of dead birds.

Producers most commonly use burial pits for the disposal of poultry carcasses. However, when residue remains in the pits after years of use or in soils with high groundwater tables, reduced surface and groundwater quality is a serious potential problem. In some states, such as Arkansas, legislation has been enacted to prohibit the use of burial pits.

Incineration is biologically the safest method of disposal. However, it is slow, expensive, and generates nuisance complaints even when highly efficient incinerators are used. Incinerators also generate particulate air pollution.

Concern over possible environmental damage and newly imposed local, state, and federal water and air quality regulations make alternative disposal methods of interest to the producer. Dead poultry composting is one such alternative that the state veterinarian's office, state and local health departments, the Alabama Department of Environmental Management, and the Soil Conservation Service (SCS) have approved.

COMPOSTING POULTRY CARCASSES

Testing and adoption of composting as a method for the disposal of poultry carcasses began in Alabama in the late 1980's. Since 1989, Alabama poultry farmers have constructed more than 600 free-standing carcass composters. Poultry producers have readily accepted the composting of poultry carcasses, but operating the composter requires a tractor with loader for loading, turning, and removing the compost.

Because large broiler farms-those with more than two houses-use tractors and loaders in their farming operations, they have readily adopted poultry composting. On the other hand, small broiler farms, those with only one or two broiler houses, do not have tractors or loaders and have hesitated in adopting composting. About 50 percent of the 3,600 Alabama broiler farms fall into this last category.

SMALL-SCALE COMPOSTING

In other states small scale producers have constructed mini-composters for use in the broiler house. Researchers at the University of Delaware tested simple, single-stage composters (Scarborough et al., 1992). These small composter bins were placed within the confines of the boiler house, and carcasses, straw, caked litter, and water were added daily. In Alabama, however, most producer usually place mini-composters outside of the broiler house (Donald et al., 1994a).

MINI-COMPOSTER CONSTRUCTION

The simplest design for a mini-composter consists of a wooden bin that will hold the dead poultry and other composting ingredients (Donald et al., 1994a). The portable composting bin developed at Auburn University is 4 feet by 4 feet and 4 feet high with removable side panels (Figure 1). The bin is constructed from pressure-treated lumber with 1/2-inch air spaces between side boards. The bin can handle normal bird mortality (two to four carcasses per thousand per day). An average 20,000-bird house requires four to five compost bins to handle normal bird mortality during a typical 7-week growout period. Small-scale composting cannot accommodate the carcasses from larger die-offs which may require other disposal methods.

In some states mini-composters are used inside the poultry house; however, at the request of the Alabama poultry industry, compost bins are placed under a small structure separated from the poultry house (Figure 2). Cost estimates for the structure and compost bins do not exceed $1500 for a two-house operation.

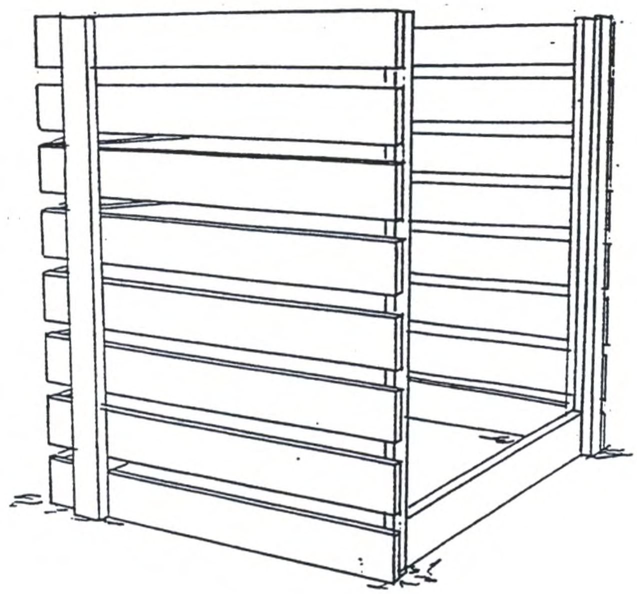


FIGURE 1. Mini-composting bins

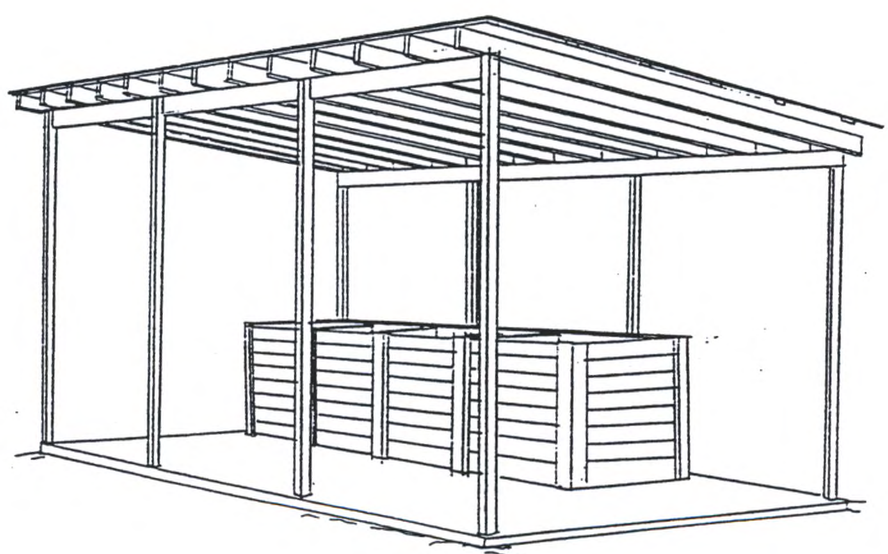


FIGURE 2. Mini-composting structure

OPERATION OF MINI-COMPOSTER

For successful operation, the composter must be properly loaded. First, a 6 to 8-inch layer of litter is placed in the bottom of the bin. An appropriate layer of straw is placed according to the composting formula and is added to aid in aeration (Table 1). After these two layers, ingredients are added according to the formula, continuing with the layer of carcasses, then a layer of litter. The carcasses need to be kept at least 6 to 8 inches away from the sidewalls of the bin. This procedure eliminates fly and odor problems. Litter is readily available as caked or uncaked material from the floor of the broiler house. If the litter is dry, water may need to be added (Donald _et al_., 1994b).

Table 1. Formula for Dead Poultry Composting

Material	Part by weight
Poultry litter	2 to 3
Straw	1/10
Carcasses	1
Water (added sparingly)	0 to 1/2

For the next and all subsequent layers, place the straw; then add carcasses and manure, in that order. As the growout proceeds, add successive layers of material to the bin. After adding the last layer, place the final cover or cap of a double layer of manure over the top. Do not add water to this final cap (Figure 3).

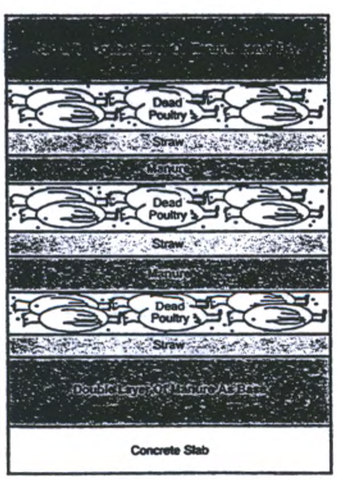


Figure 1. Laying of ingredients in composting bins.

The primary purpose of straw is to add air voids and allow aerobic decomposition of the moisture. Many producers who use caked material have successfully composted without straw, but individual producers must decide whether or not to use straw; however, proper management of the bin becomes much more important.

When adding additional water for composting, keep in mind the moisture content of the litter. The moisture content of poultry litter or cake may vary from 20 to 40 percent depending on the source. In small-scale composting, adding water to achieve a 50- to 60-percent moisture content is much more important than in large-composter management.

Monitor the temperature in the compost bin with a 20-inch, probe-type thermometer. After a few days, temperatures increase rapidly because of bacterial action, rising to 130 F or greater. After 7 to 10 days, the bin reaches its high reading of 130 to 150 F, which helps stabilize the compost. Once temperatures begin to decrease, you can easily move the composted material to storage.

MICROBIOLOGICAL STUDIES

To address biosecurity concerns, mini-composters have been microbiologically evaluated during several growing cycles (Kotrola et al., 1993). Samples obtained from different locations within each mini-composter bin were analyzed for populations of coliform bacteria and Enterobacteriaceae, as well as for the presence of Salmonella spp., Campylobacter jejuni, and Listeria monocytogenes. Coliform bacteria were found in low numbers (<5600 cfu/g) in only three of 30 samples. In all other samples, coliform bacteria and Enterobacteriaceae were not detected (<10 cfu/g). Furthermore, no viable Salmonella, C. jejuni or L. monocytogenes were recovered from any of the samples. This preliminary information indicates that mini-composting shows promise as a biosecure method of carcass disposal.

LAND APPLICATION OF COMPOST

Composted carcasses can be stored until proper time for land application to fulfill nutrient requirements of the field or forage crop. Nutrient content of the composted carcasses will vary depending upon the nutrient content of the manure, the age of the compost, and method of storage. When land-applied like fertilizer, composted material should be applied as close to planting as possible and should be incorporated with normal soil tillage operations. In general, the nutrient content of the composted broiler carcasses is:

- Moisture 28.0%
- Nitrogen 1.9%
- Phosphorus 2.3%
- Potassium 1.6%

SUMMARY

Alternative methods for the disposal of poultry carcasses are limited, and mini-composting presents itself as a desirable environmental and economic option. Applied research conducted at Auburn University in the early 1990's demonstrated that small-scale composting puts an effective and simple composting system within the reach of virtually every poultry producer.

The mini-composter fills the need for a small, simple composter that can process complete growout mortality on small-size farms. The operation is simple, yet highly effective, and construction costs are reasonable.

REFERENCES

Donald, J. O., J. P. Blake, K. Tucker, and D. Harkins, 1994a. Mini-composters in poultry production. Circular ANR-804. Alabama Cooperative Extension Service, Auburn University, AL.

Donald, J. O., J. P. Blake, K. Tucker, and D. Harkins, 1994b. Questions and answers about mini-composters. Circular ANR-850. Alabama Cooperative Extension Service, Auburn University, AL.

Kotrola, J. S., D. E. Conner, J. P. Blake, and J. O. Donald, 1993. Microbiological evaluation of small-scale in-house composting of poultry carcasses. Poultry Sci. 72(1):78.

Scarborough, J. N., D. H. Palmer, and T. H. Williams, 1992. Composting structures for dead poultry disposal. Circular EQ-4. University of Delaware Cooperative Extension, Newark, DE.

VALUE OF BROILER POULTRY LITTER AS FEED FOR BEEF CATTLE

T. A. McCaskey, Professor, Dept. Animal & Dairy Sciences
Auburn University, Auburn, AL 36849
B. G. Ruffin, Beef Cattle Nutritionist, Cooperative Extension Service, Auburn University, Auburn, AL
J. T. Eason, Superintendent, Sand Mountain Substation, Alabama Agricultural Experiment Station
Crossville, AL
R. C. Strickland, Project Manager, Biochemical Research Department, TVA, Muscle Shoals, AL

Broiler poultry growers generate large quantities of litter composed of poultry excreta, bedding material such as wood chips, wasted feed and feathers. The feed value of poultry litter for ruminants was reported nearly 30 years ago by Bhattacharya and Fontenot (1965). The recommended use of litter for feeding is usually for beef brood cows and for stocker cattle which are not destined for immediate slaughter. Concerns about residue carry-over from the litter to the carcass of the slaughtered animal are, thereby, eliminated. Litter is not recommended for feeding to fatten cattle because the litter is relatively low in energy. Inclusion of litter in diets of fattening cattle tends to dilute the energy level of the total diet, thereby reducing gains of the feedlot cattle. This limitation of litter has a desirable effect, because it discourages the feeding of litter to fattening cattle, which are destined for slaughter and marketing to the public. Other measures also ensure the safety of poultry litter as a feed source for ruminants. All litter offered for sale as a feed must be processed to ensure the safety of the litter from enteric pathogens. State Departments of Agriculture that permit marketing of litter require the litter processor/marketer to be licensed and to keep detailed records of the raw and finished products. Furthermore, the litter offered for sale must be free of pathogens and unapproved residues, and meet all state regulations pertaining to feed safety. The Association of American Feed Control Officials began development of model regulations for use of animal wastes as feed ingredients in about 1977 (Minyard 1977) and officially adopted the regulations in 1982 (AAFCO 1983). Twenty-one states had feed laws in 1989 that permitted the marketing of broiler litter as feed (McCaskey et al., 1990), and interest in the feeding of broiler poultry litter has steadily increased in the southern U.S. in recent years. Two factors are associated with the increased use of litter as a feedstuff. In the southern states where most of the broiler poultry are grown, litter is readily available. Secondly, because litter is plentiful, it is economical. Many broiler producers also produce beef cattle because they have access to a readily available, low cost, feed ingredient. The practice of feeding litter dates back to the early 1960's when researchers in Virginia first drew attention to the economics of feeding litter to beef cattle. Interest in this practice was emulated by researchers in Alabama in the late 1960's. In Virginia and Alabama broiler litter has been fed successfully to beef cattle for about 30 years. Due to successful implementation of the practice in these states, the practice has been adopted by beef cattle producers in several southern states. Interest in feeding litter has grown substantially in recent years because it represents the highest economic return for litter, and recycling of by-products in general has become more acceptable to the public. However, some beef cattle producers fear potential public criticism regarding the feeding of broiler litter, and although they are interested in feeding broiler litter, have refrained from the practice.

Economics is the major motivation for the use of broiler litter as a feedstuff. The value of litter has been estimated to range from $59/ton (Free 1977) to $114/ton (Stephenson 1990) based on the nutrient value of litter components. Zimet et al. (1988) valued litter at $684/ton based on the value of pasture equivalents spared by feeding litter. These estimates of the feed value of litter have merits, but they are not based on performance of animals fed a litter-based diet compared to animals fed a conventional diet. A study was conducted to determine the feed value of a litter-based diet based on animal performance relative to the performance of animals fed a conventional diet.

MATERIALS AND METHODS

Thirty-six crossbred heifers, initially weighing 548 pounds, were purchased, vaccinated, dewormed, implanted and sorted into six groups of six animals each. After a 28-day adjustment period, three groups were fed a conventional diet and three were fed a corn:litter diet. The cattle were housed in pens in an open-sided barn with a concrete floor, and manure was removed from the barn twice daily. Water was available at all times during the 112-day feeding trial, but the cattle were not fed any hay.

The heifers were fed either a conventional diet containing corn, soybean meal, and cottonseed hulls, or a 50:50 mixture of corn and broiler poultry litter (Table 1). The diets were formulated to provide approximately the same amounts of nutrients (Table 2). Broiler litter with 24.5% crude protein (dry basis), 17.9% ash and 29.1% crude fiber was deep-stacked in a pole barn, covered with polyethylene sheeting, and stored 28 days before use. Proximate analysis of the broiler litter and the feed samples was conducted by AOAC procedures (AOAC 1984).

Table 1. Composition of conventional and corn:litter feeds

Ingredient	Conventional	Corn:litter
	pounds/ton	pounds/ton
Cottonseed hulls	501.0	-
Soybean meal, 44%	160.0	-
Corn grain	1,218.0	1,000.0
Broiler litter	-	999.0
Urea	40.0	-
Minerals	80.0	-
Vitamin A-30	0.5	0.5
Bovatec™	0.5	0.5

Table 2. Proximate analysis of feeds[a)]

	Conventional	Corn:litter
Dry matter, %	89.1	83.9
	- - - - % of DM	- - - -
Ash	6.9	9.9
Nitrogen (N)	2.9	2.7
Crude protein	17.9	16.7
Acid detergent fiber	18.2	18.7
Ether extract	1.6	1.3
Crude fiber	11.7	11.6
Bound N, % of total N	7.1	9.6
TDN[b], %	71.3	69.7

[a]Data are means from analysis of six feed samples.
[b]Calculated using acid detergent fiber

RESULTS AND DISCUSSION

The heifers fed the conventional diet gained 283 pounds during the 112-day feeding trial, and the heifers fed the corn:litter diet gained 238 pounds (Table 3). Daily intake of the conventional and corn:litter diets was similar at 22.1 pounds vs 22.9 pounds. Average daily gain of heifers fed the conventional and corn:litter diets, 2.53 pounds vs 2.12 pounds, respectively, was not different ($p<0.05$). However, heifers fed the conventional diet were more efficient in feed conversion than those fed the corn:litter diet, 8.7 vs 10.8 pounds feed/pound gain.

Table 3. Animal performance data for 112-day feeding trial

Variable	Conventional	Corn:litter
Initial weight (pounds)	550	546
Day 112 weight (pounds)	833	784
Gain (pounds)	283	238
Avg. daily gain (pounds)	2.53	2.12
Intake (pounds)	22.1	22.9
Feed:Gain	8.7:1	10.8:1
Feed cost/ton ($)	152	84
Feed cost/pound (cents)	7.6	4.2
Cost/pound gain (cents)	66	46

Feed cost for the conventional diet, based on current market prices for the ingredients, was $152/ton of feed, and $84/ton for the corn:litter diet (Table 3). Corn cost was $140/ton and the cost of the litter was $27.50/ton. Although average daily gain of cattle fed the corn:litter diet was not as high as that of the cattle fed the conventional diet, cost/gain favored the corn:litter diet (Table 3). Using the feed:gain ratios of 8.7 and 10.8, and cost/ton of $152 and $84 for the conventional and corn:litter feeds, respectively, the cost/pound of gain for the corn:litter feed was $0.46 and $0.66 for the conventional feed. The break-even cost for the corn:litter feed when compared to the conventional feed is $123/ton. This indicates that a beef producer could pay up to $0.061/pound, or $123/ton, for the corn:litter feed, and feed costs relative to animal performance would favor the corn:litter diet. But as the cost of the corn:litter feed increases above the $123/ton, the economic advantage of feeding litter is diminished because it becomes more expensive relative to animal performance than the conventional diet.

The economic advantage of feeding broiler litter becomes apparent when beef cattle producers procure litter at low cost and blend their own 50:50 corn:litter diets. The difference between the break-even cost of $123/ton and the cost for a producer to blend his own corn:litter diet represents the economic advantage of feeding litter. Because all broiler litter is not of acceptable quality for feeding, producers should select litter that contains less than 25% moisture and less than 28% ash. The crude protein content of the litter should be 18% or higher and the bound protein should not exceed 25% of the total crude protein (Ruffin 1991). Composted litter does not meet these quality guidelines and should not be used as a feed ingredient.

CONCLUSIONS

Stocker cattle fed a 50:50 corn:litter diet had similar feed intake and average daily gain as cattle fed a conventional ingredient diet during a 112-day feeding trial. Based on the feed:gain ratios of 10.8 and 8.7, and cost/ton of $84 and $152 for the corn:litter diet and conventional diet, respectively, the cost/pound of gain was $0.46 for the corn:litter diet and $0.66 for the conventional diet. The break-even cost for the corn:litter diet was $0.061/pound or $123/ton, which indicates that as the cost of the corn:litter diet increases above this level, the economic advantage of feeding litter is lost.

REFERENCES

AAFCO, 1983. Official publication, Association of American Feed Control Officials. College Station, TX, p. 153-155.

AOAC, 1984. Official methods of analysis (14th Ed.). Association of Official Analytical Chemists, Washington, D.C.

Bhattacharya, A.N., and J.P. Fontenot, 1965. Utilization of different levels of poultry litter nitrogen by sheep. J. Anim. Sci. 24:1174-1178.

Free, J.W., 1977. Economic aspects of feeding waste to ruminants. In: Proceedings Alternative Nitrogen Sources for Ruminants, Nov. 9-11, Atlanta, GA, p. 86-90.

McCaskey, T.A., A.H. Stephenson, and B.J. Ruffin, 1990. Factors that influence the marketability and use of broiler litter as an alternative feed ingredient. In: Proceedings of the Sixth International Symposium on Agricultural and Food Processing Wastes, Dec 17-18, Chicago, IL, p. 197-203.

Minyard, J.P., 1977. Regulation of recycled wastes as animal feeds in Mississippi. In: Proceedings Alternative Nitrogen Sources for Ruminants, Nov. 9-11, Atlanta, GA, p. 82-85.

Ruffin, B.G. and T.A. McCaskey, 1991. Feeding broiler litter to beef cattle. Circular ANR-557, Alabama Cooperative Extension Service, Auburn, AL 36849.

Stephenson, A.H., T.A. McCaskey, and B.G. Ruffin, 1990. A survey of broiler litter composition and potential value as a nutrient resource. Biolog. Wastes. 34:1-9.

Zimet, D.J., M.D. Ouart, and D.L. Prichard, 1988. Research note: Use of computer simulation to determine the value of broiler litter as a cattle feed ingredient. Poultry Sci. 67:1352-1355.

CHEMICAL PRESERVATION OF WHOLE BROILER CARCASSES UTILIZING AQUEOUS ALKALINE SOLUTIONS

D.J. Shafer and J.B. Carey
Department of Poultry Science
Texas A&M University
College Station, TX 77843

The utilization of broiler mortalities, as a quality source for rendered poultry meal products, may be enhanced by preservation in aqueous alkaline hydroxide solutions. The holding of on-farm mortalities in strongly alkaline solutions (pH >13) could provide a storage system that precludes microbial transmission or pest infestation while simultaneously hydrolyzing carcass feathers. An alkaline chemical preservation system could prove advantageous due to low resource input and ease of maintenance. The exclusion of putrefaction or rancidity would allow for holding of carcasses without excessive odors being generated.

HISTORICAL AND ENVIRONMENTAL PERSPECTIVE

Consideration of a chemical method to preserve poultry production mortalities can find historical basis within early agriculture and food preservation methods. The preservative action of acidic solutions have been used by man to maintain beverage and food quality as a matter of survival from disease and famine. Historically pH and chemistry were used by man to preserve, stabilize or enhance foods such as ciders, wines, pickled meats and vegetables (Ayres et al., 1980). Alkalinity has been used in the past to make roughage nutrients more available for ruminants and to soften and stabilize grains for human consumption.

Treatment of poultry mortalities with acids or inoculates of acid producing bacteria has been investigated as a method of carcass preservation. Dobbins (1988) reported fermentation by Lactobaccilus as a method to preserve poulty carcasses. Murphy and Silbert (1990) found acidophilic, anaerobic bacteria produced semi-liquid poultry silage. Sufficient acid preservation to prevent spoilage organisms using acid solutions was reported by Malone (1990).

Manipulation of pH by microbial or acid addition has proven effective in controlling putrefaction. However these methods often require grinding of the carcass to allow adequate infusion or addition of carbohydrate substrates to support initial microbial growth. These steps add time and expense to the processes. Additionally, it may not be prudent to generate large quantities of stongly acidic product that could contribute to the introduction of acidic residuals into wastewater discharge. Residuals from the processing of alkaline preservation carcasses may offer the additional benefit of providing a valuable source of buffering agent for acidic wastewater discharge.

In response to these concerns the utilization of alkaline aqueous solutions may provide an effective alternative for stabilization and simultaneous solubilization of broiler carcasses from mortalities. Alkaline hydroxides can provide an environment of extremely high pH (> 13) in which very few organisms can survive. Alkaline hydroxides are corrosive, thus having dissolving and disinfecting properties (Kramer and Twigg, 1973). Potassium hydroxide (KOH) and sodium hydroxide (NaOH) are considered to be strongly reactive. Sodium hydroxide, commonly called caustic soda or lye is readily available and shipped by commercial carriers. Sodium hydroxide is used in commercial food processing for cleaning. Hydroxides of other sources such as calcium (CaOH) and magnesium (MgOH) have the same basic acceptance for shipping and handling. Sodium hydroxide is commercially available at lower cost and greater purity (97%) than potassium hydroxide (85.6%). However, potassium hydroxide may prove to be cost effective, by virtue of greater alkaline activity. The comparison of alkaline concentrations of strong solutions is expressed more effectively as moles per liter or molar concentration (M), to evaluate chemical activity and capacity.

EXPERIMENTAL DESIGN

Experiments were conducted to examine the effects on carcasses treated with different alkaline hydroxide sources and concentrations. Experiments were conducted using a factorial arrangement of 4 treatments with 3 replications per treatment, using a total of 12 broiler carcasses per experiment.

Broilers of 6 weeks of age or older were euthanized by carbon dioxide induction. Broiler carcasses were then punctured with a stainless steel processing knife on each side of the abdomen and the blade forced into the thoracic cavity, to allow disruption of both major body cavities. Individual carcasses were placed in commercial polyethylene smoke nets with both ends secured with commercial plastic zip ties.

Solutions were prepared using reagent grade granular or pelleted hydroxides. Carcass and solution weights were recorded in grams at the start and finish of each experiment. Each carcass was placed in 8 liters of treatment solution. Polyethylene 15 liter containers with lids were used to hold solution and carcass.

Samples were collected at the conclusion of the experiments for analysis of pH, dried solids, protein and microbiology. Solids samples were dried for 24 hours at 105oC in a mechanical convection oven (AOAC, 1984). Protein was analyzed using a Leco® FP-428 Nitrogen Determinator (St. Joseph, MI) and converted to protein values by multiplying by 6.25. Extensive photography was taken to document external and internal changes of carcasses and solutions. Samples of solutions, skin and intestine were incubated on tryptic soy agar at 37°C and examined for microbial growth at 24 and 48 hours.

Data from experiments were analyzed independently with main effects of hydroxide, concentration and replicate. The two-way interactions of the main effects were also included as sources of variation. Statistical calculations were processed by computer using SAS statistical analysis software program, version 6.04. Mean separations were accomplished by utilization of the PDiff option of the General Linear Model procedure (SAS, 1990). All statistical comparisons were considered significant at $P < .01$.

Experiments

Experiment 1: Solutions consisted of Molar (M) concentrations of 1.9 M NaOH (Sodium Hydroxide) or 1.9 M CaOH (Calcium Hydroxide) or 1.6 M KOH (Potassium Hydroxide) or 3.5 M MgOH (Magnesium Hydroxide). Experiment duration was 5 days.

Experiment 2 and 3: Solutions consisted of .48, .97, 1.4, or 1.9 M concentrations of NaOH. Experiment duration was 10 days.

Experiment 4: Solutions consisted of .12, .24, .36, or .48 M concentrations of NaOH. Experiment duration was 10 days.

Experiment 5 and 6: Solutions consisted of .48, .72, .97, or 1.2 M concentrations of NaOH. Experiment duration was 10 days.

Experiment 7: Solutions consisted of 2 M KOH or 2 M NaOH or 1.5 M KOH and .5 M NaOH or 1.5 M NaOH and .5 M KOH. Experiment duration was 10 days.

RESULTS

Experiment 1

By Day 5 carcasses were visibly degraded and without the majority of feathers in the solutions of sodium or potassium hydroxide by Day 5. Calcium and magnesium hydroxide did not achieve any visible degradation of the carcasses or feathers. Calcium and magnesium hydroxide carcasses were swollen and strong in odor. Sodium and potassium hydroxides produced degradation past the skin and into the musculature and internal organs. Most noticeable was the fresh bright red color of the flesh, with the breast muscles having a frozen appearance. Internal organs were partially degraded in the thoracic cavity. The abdominal organs were intact except for the intestines which had solubilized in certain areas exposed to the solution. Heads and feet had a tendency to degrade. Some heads were solubilized completely in the sodium hydroxide treatments. Odor was minimal and characterized as that of a slight chemical or soap smell. There appeared to be the production of a crude saponified product from the skin and subcutaneous fat reacting with the hydroxides. No viable bacteria were recovered from any of the solutions. The pH was not observed to decrease in the sodium and potassium solutions. Solids and protein values were significantly greater when comparing NaOH or KOH to the CaOH or MgOH solutions. Solids of the KOH and NaOH solutions were 20.68 and 20.06 respectively, and were not significantly different (Table 1).

Table 1. Comparison of Solids and Protein Composition of Different Alkaline Hydroxide Solutions After 5 Day Treatment of Broiler Carcasses (Experiment 1)

Treatment	Concentration[a] (M)	Solids (%)	Protein (%)
NaOH	1.9	20.06^A	$.91^A$
CaOH	1.9	9.62^B	$.05^B$
KOH	1.6	20.68^A	1.06^A
MgOH	3.5	9.60^B	$.19^B$

[a]Alkaline hydroxide expressed as moles/liter concentration.
[A,B]Means with no common superscripts within columns differ significantly (P <.01).

Experiment 2 and 3

The .48, .97, 1.4, or 1.9 M solutions of sodium hydroxide were examined in duplicate experiments. Lower concentrations of sodium hydroxide resulted in extensive carcass and feather degradation at the .97, 1.4 M solution strength. Feathers were not removed completely at these strengths, but 1.4 M samples were quite advanced by Day 10. Skin and muscle degradation were extensive in some samples and not in others. Odor was minimal in the 1.4 and 1.9 M treatments but was noticable in the .48 and .97 M treatments. The 1.9 M solutions showed continued degradation of carcasses with no feathers remaining and minimal odor. Bacteria were not recoverable from the solutions and skin of the 1.4 and 1.9 M treatments. Microbial growth was observed from skin and intestine samples of the .48 and .97 M treatments. The percentage of solids and protein in the solutions increased significantly as NaOH concentration increased (Table 2). The 1.9 M treatment produced solids above 20.0% and protein above 1.0% in both experiments.

Table 2. Comparison of Solids and Protein Composition of Different Concentrations of Sodium Hydroxide Solutions After 10 Day Treatment of Broiler Carcasses (Experiment 2 and 3)

	Experiment 2		Experiment 3	
NaOH (M)[a]	Solids (%)	Protein (%)	Solids (%)	Protein (%)
.48	9.69^{D}	$.45^{C}$	9.63^{D}	$.42^{C}$
.97	12.69^{C}	$.55^{C}$	12.76^{C}	$.65^{BC}$
1.4	18.73^{B}	1.46^{B}	18.10^{B}	$.91^{B}$
1.9	21.54^{A}	3.19^{A}	22.05^{A}	1.84^{A}

[a]Alkaline hydroxide expressed as moles/liter concentration.
[A,B,C,D]Means with no common superscripts within columns differ significantly ($P < .01$).

Experiment 4

The lowest concentrations examined .12, .24, .36 or .48 M of sodium hydroxide gave mixed results. A majority of carcasses from the treatments were very swollen and had minimal feather degradation, though feathers were loosened from the carcasses at the .36 and .48 NaOH concentration. All carcasses were characterized by strong and extremely putrid odors. One carcass in the .36 and .48 M treatments had visibly degraded further than other specimens. Decline in pH was evident in all treatments. Bacterial growth was evident from all concentrations except for .48 M. The percentage of solids in the solutions increased significantly as NaOH concentration increased. The .48 M treatment produced solution solids of 5.11% and solution protein of .41%. These values were significantly greater than the means of the .12, .24 and .36 M treatments (Table 3).

Table 3. Comparison of Solids and Protein Composition of Different Concentrations of Sodium Hydroxide Solutions After 10 Day Treatment of Broiler Carcasses (Experiment 4)

NaOH (M)[a]	Solids (%)	Protein (%)
.12	3.37[C]	.03[B]
.24	3.41[C]	.14[B]
.36	4.15[B]	.16[B]
.48	5.11[A]	.41[A]

[a]Alkaline hydroxide expressed as moles/liter concentration.
[A,B,C]Means with no common superscripts within columns differ significantly ($P < .01$).

Experiment 5 and 6

The .48, .72, .97, or 1.2 M solutions of sodium hydroxide were examined in duplicate experiments. These treatments gave mixed results. The majority of feather and carcass degradation occurring in the .97 and 1.2 M solutions. The .48 and .72 treatments did effectively loosen and soften those feathers which remained. In Experiment 5, the .48 and .72 M treatments had visibly greater degradation of feathers than the same treatments of Experiment 6. Microbial growth was achieved from samples of skin and intestine of all treatments, but not from all samples. Change in pH was evident in the .48, .72 and .97 M treatments. Each incremental change in NaOH concentration produced significant increases in solution solids and protein content (Table 4).

Table 4. Comparison of Solids and Protein Composition of Different Concentrations of Sodium Hydroxide Solutions After 10 Day Treatment of Broiler Carcasses (Experiment 5 and 6)

NaOH	Experiment 5		Experiment 6	
(M)[a]	Solids (%)	Protein (%)	Solids (%)	Protein (%)
.48	4.20[D]	.86[B]	4.89[D]	1.19[A]
.72	5.03[C]	1.41[A]	9.14[C]	1.47[A]
.97	12.10[B]	1.67[A]	12.40[B]	1.31[A]
1.2	15.72[A]	1.47[A]	14.16[A]	1.48[A]

[a]Alkaline hydroxide expressed as moles/liter concentration.
[A,B,C,D]Means with no common superscripts within columns differ significantly (P <.01).

Experiment 7

Solids and protein values were significantly different when comparing 2 M KOH or 1.5 M KOH and .5 NaOH to the 2 M NaOH or 1.5 M NaOH and .5 M KOH solutions. However, comparisons between the KOH or NaOH as major hydroxide source, found no significant difference between the 2 M and 1.5 M treatments. Potassium hydroxide at 2 M and 1.5 M cocentrations produced the highest percentages for solution solids and protein among all treatments investigated (Table 5).

Table 5. Comparison of Solids and Protein Composition of Different Alkaline Hydroxide Solutions After 10 Day Treatment of Broiler Carcasses (Experiment 7)

Treatment	Concentration[a] (M)	Solids (%)	Protein (%)
NaOH	2.0	24.40[B]	1.93[B]
NaOH + KOH	1.5 .5	25.04[B]	2.26[B]
KOH + NaOH	1.5 .5	36.16[A]	3.83[A]
KOH	2.0	36.04[A]	4.55[A]

[a]Alkaline hydroxide expressed as moles/liter concentration.
[A,B]Means with no common superscripts within columns differ significantly (P <.01).

Carcasses were almost completely solubilized in the 2 M potassium hydroxide and 1.5 M potassium hydroxide with .5 M sodium hydroxide. A product that was extensively degraded and without feathers was achieved by the solutions of 2 M sodium hydroxide and 1.5 M sodium hydroxide with .5 M potassium hydroxide. No viable bacteria were recovered from any of the solutions. Skin and intestine samples were not retrieved due to the high degree of degradation. No decline in pH was observed in the solutions.

DISCUSSION

The utilization of sodium hydroxide and/or potassium hydroxide solutions to maintain poultry carcasses without putrefaction was effective. As concentration of hydroxide increased the degree of carcass degradation increased, thus increasing the solids and protein content of the solution. The increase in solution solids was well beyond that contributed by the chemical addition of hydroxide. KOH and NaOH, individually or combined, provided extremely low pH environment that hydrolyzed feathers and solubilized skin, fat and musculature of poultry carcasses. The stronger the molar concentration of solution the more resilient the solution was to pH change, microbial growth and odor production. The range of concentrations studied demonstrated that sodium hydroxide can be used to loosen feathers from the skin or solubilize feathers and carcasses extensively. Potassium hydroxide was found to achieve greater degree of carcass solubilization when compared to sodium hydroxide. The KOH and KOH with NaOH treatments produced the highest concentration of solution solids and protein, of all experiments conducted in this study. Potassium hydroxide at 2M concentration or 1.5 M with .5 M NaOH mixture was capable of rendering broiler carcasses into a liquid state over a 10 day interval.

REFERENCES

AOAC, 1984. Association of Official Analytical Chemists. Official Methods of Analysis, 14th edition. Washington, DC.

Ayres, J.C., J.O. Mundt and W.E. Sandine, 1980. Chemicals in foods. In Microbiology of Foods. W.H. Freeman and Company, San francisco, CA. p 123-144.

Dobbins, D.N., 1988. Lactobacillus fermentation: A method of disposal/utilization of carcasses or toxic chemicals. Proceedings, National Poultry Waste Management Symposium. p 76-80.

Kramer, A. and B.A. Twigg, 1973. Sanitation. In: Quality Control For The Food Industry. Vol.2, Third Ed. AVI Publishing Company, Inc., Westport, CT. p 389-414.

Malone, G.W., 1990. Carcass preservation systems - Acid preservation and proteolytic yeast. Proceedings, National Poultry Waste Management Symposium. p 52-55.

Murphy, D.W. and S.A. Silbert, 1990. Carcass preservation systems - Lactic fermentation. Proceedings, National Poultry Waste Management Symposium. p 56-58.

SAS Institute, 1990. SAS User's Guide: Statistics. Release 6.04. SAS Institute Inc., Cary, NC.

POULTRY PRODUCERS' PRACTICES AND ATTITUDES REGARDING WASTE MANAGEMENT[1]

Thomas Hoban
Extension Specialist -- Sociology

Thomas Carter
Extension Specialist in Charge -- Poultry Science

William Clifford
Department Head -- Sociology

North Carolina State University
Raleigh, NC 27695-8107

Waste management is now recognized as an important social and political issue. The public is increasingly concerned about the odor and water pollution impacts of livestock and poultry waste. Fortunately, practices are generally available for minimizing the impacts of waste on the environment. Not all producers, however, are willing and able to use such practices. To address public concerns, North Carolina recently enacted regulations that require some poultry producers to implement waste management practices within the next few years.

This paper examines the poultry producers attitudes and practices related to waste management. Results are from a statewide telephone survey conducted in early 1994 with over 400 North Carolina poultry producers. The sample included the following types of operations, selected at random from lists provided by the N.C. Department of Agriculture: broiler producers (n= 169), broiler breeders (n=134), and turkey growers (n=112). For this paper, information is presented about their adoption of waste management practices, as well as their attitudes about the practices and government policies.

[1]Funding for this project was provided by the N.C. Agricultural Research Service. This project involved a multidisciplinary team of Extension Specialists and othrs, including: Jim Barker, Geoff Bensen, Bob Bottcher, Roger Crickenberger, Frank Humenik, Bob Jones, Dale Miller, Morgan Morrow, Don Wesen, Kelly Zering, and Joe Zublena.

Differences in waste management practices and attitudes based on type of poultry operation are also examined.

WASTE MANAGEMENT PRACTICES

Poultry producers were asked about practices they used both for managing litter and cake. One half of the whole sample reported that they roto-tilled or mixed litter between flocks. However, we found significant differences between the operations. Almost all (87 percent) of the turkey growers mixed their litter. However, less than half of the broiler producers and only 25 percent of the broiler breeders reported this practice. Almost 85 percent of all the producers remove cake from their houses between flocks. Differences also exist in terms of who does the work. Of the broiler producers, 38 percent have a custom operator do it. About half the broiler-breeders use a custom operator. More (60 percent) turkey growers use custom operators. Once the cake is removed from the houses, over a third of all respondents said it is all removed from the farm.

Some significant differences were found in terms of how often the producers completely clean out their poultry houses by removing all litter and bedding. Most (85 percent) of the broiler breeders completely clean the houses after every flock. On the other hand, over three quarters of the broiler producers only clean out their houses completely after every fourth flock or even less often. Turkey growers are in the middle. About 40 percent clean out their houses after every flock, but just as many only do it after every fourth flock or less often. Differences exist in how many producers use custom operators for cleaning their houses: turkey growers (82 percent), broiler breeders (69 percent), and broilers (52 percent). Just under half (47 percent) of all producers said that all the litter and bedding is removed from the farm after the houses are cleaned.

Land application of litter and cake is an important waste management practice. Almost three quarters (73 percent) of the respondents reported that their waste is applied either to their own land or somewhere else. Producers again vary in terms of their use of custom operators for land application: broiler growers (28 percent use custom operators), broiler breeders (34 percent), and turkey growers (58 percent). We also note some significant differences in terms of the amount of land used for application of poultry litter. Turkey growers reported the highest amount, with an average of 117 acres. The other two groups reported much less land used for application:

broiler producers (63 acres) and broiler breeders (53 acres).

In terms of type of equipment used for land application, over half (60 percent) of those who land apply use a spinner spreader. Another 18 percent use a box spreader, while 23 percent use some other type of equipment. Only 41 percent had their equipment calibrated in the last five years. Turkey producers reported the greatest calibration (64 percent) compared to broiler breeders (44 percent) and broiler producers (34 percent). Just over half (55 percent) of all those who land applied, reported that they had buffer strips, terraces, or other water quality control practices installed on the fields where they apply litter. Almost all (94 percent) of those who land applied indicated that they had reduced their cost of fertilizer by using poultry litter on their land.

WASTE MANAGEMENT DECISION MAKING

Another important aspect of poultry waste management involves the extent to which land application and other waste management practices are carefully planned and monitored. One of the keys to effective waste management is to have a systematic waste management plan prepared by a professional agricultural scientist or technician. Just over one quarter of all the poultry producers reported having a written waste management plan. Of those who had a plan, reported implementation was fairly high (average of 78 percent for the 110 producers with a plan). No differences in planning were found between types of operation.

Effective waste management planning will also require factual information about the nutrient value of both the soil and waste material. Over half (55 percent) of all producers reported having had their soil tested for nutrients during the previous five years. The number reporting soil tests was higher for turkey growers (76 percent) and broiler-breeders (61 percent) than for the broiler producers (47 percent). Just over a third (37 percent) of all producers reported having had their poultry litter or cake tested for nutrients during the previous five years. Again, turkey growers were much more likely to report such testing than the other groups.

A number of different factors can influence producers' willingness and ability to successfully implement waste management practices. This is particularly true for those practices which are relatively new or unfamiliar. Respondents were asked "How important are each of the following in your decisions about which practices you choose to manage or use your poultry litter -- very important (3), somewhat important (2), or not important(1)?" Results are shown in Table 1, indicating any differences between the three groups of poultry producers.

The most important influence on producers' waste management decisions involves the ability of the practice to control water pollution. We find six other influences clustered in the middle, in terms of importance: cost of the practice; potential to reduce odor; ability to grow profitable crops; how easy practice is to use; labor or time required; and availability of land. Two factors appear less important, namely the experience of other poultry growers and government cost-sharing. Turkey growers generally rated each factor as having a greater influence. The differences are most significant for the ability to grow profitable crops and how easy the practice is to use.

Table 1. "Very Important" Influences on Waste Management Decisions[a]

	Broiler Growers	Broiler-Breeders	Turkey Growers	Whole Sample
Water pollution control	64%	63%	71%	65%
Cost of the practice	48%	50%	67%	53%
Ability to grow profitable crops	46%	48%	69%	51%
Potential to reduce odor	51%	46%	54%	50%
Labor or time required	39%	45%	55%	44%
How easy practice is to use	39%	40%	54%	42%
Availability of land	38%	40%	55%	42%
Experience of other poultry growers	24%	20%	31%	24%
Government cost-sharing	18%	23%	28%	21%

[a]Results shown are the percentage of producers who said that each influence was "Very Important" in their decisions. The remainder said the factor had either "Some" or "No" influence on their decision.

Another important factor that could have an influence on poultry producers' decisions about the use of waste management practices will be the amount of information available from various sources. We asked respondents to rate each of six information sources by asking "How much useful information have you received from the following about ways to use or manage poultry litter -- a lot (3), some (2), or none (1)?" Results are shown in Table 2.

Producers in this survey seem to be getting useful information from four of the sources. Farm magazines and newspapers are the most useful source. Three other sources are seen as "useful" by over half the respondents: the Soil Conservation Service, the Cooperative Extension Service, and other poultry producers. Tours and demonstrations provide useful information to only about one-third of the producers. Fertilizer dealers provided relatively little useful information about waste management. Turkey growers tended to report getting more information from each of the sources than did the other types of producers.

Table 2. Sources of "Useful" Information About Waste Management[a]

	Broiler Grower	Broiler-Breeders	Turkey Growers	Whole Sample
Farm magazines or newspapers	64%	60%	77%	66%
The Soil Conservation Service	58%	50%	70%	59%
The Cooperative Extension Service	55%	62%	70%	59%
Other poultry growers	58%	40%	57%	54%
Tours and demonstrations	33%	29%	34%	33%
Fertilizer dealers	12%	9%	21%	14%

[a]Results shown are the percentage of producers who said they had received either "Some" or "A Lot" of information from each source. The remainder said they had gotten "None."

To determine the need for more information, producers were asked "Overall, how much more information or technical assistance do you need about how to better use poultry litter?" Half the producers said they needed "none." Another 18 percent said they only needed "a little" more information. Over a quarter (28 percent) indicated that they needed "some". Only six percent said they needed a lot more information. These results indicate that most producers feel they have most of the information or assistance they need.

Other results also indicate satisfaction with current practices and general resistance to change. When asked directly, almost all respondents (91 percent) said they do not plan to make any changes in the way they manage poultry litter or cake. Almost as many (88 percent) said they were very satisfied with their current litter management system in terms of water pollution control. In addition, over three quarters said they were very satisfied with their current litter management system in terms of odor control. No significant differences were found among the different poultry types in response to these questions.

PUBLIC POLICIES AND ISSUES

Public policies and issues can have an important influence on poultry producers' waste management decisions. Respondents were read the following statement: "The N.C. Environmental Management Commission recently passed new rules about livestock and poultry waste. These require that certain poultry and livestock producers register with the state by December 31, 1993. These producers will then need to develop and implement a waste management plan." Almost half (47 percent) of all respondents had not even heard of these rules. Awareness varies by type of operation. Almost three quarters of the turkey growers had heard of the rules, compared to only 45 percent of the broiler producers.

Those 220 producers who had heard of the rules were asked some additional questions. Almost all (99 percent) of the respondents indicated that they believed their poultry operation was already in compliance with the regulations. However, only half the turkey growers (and only a third of the other groups) had already registered their operations with the state (in early 1994). It is important to note that some operations had not, in fact, been required to register at this time. Respondents' views about the impacts of these rules varied considerably. One quarter felt the rules would have "a lot" of influence on the way they manage poultry litter. However, one third felt the rules would have "no influence." Almost a quarter felt the regulations would have a negative effect on their profits. However, 14 percent expected a positive effect on profits. Most (63 percent) saw no effect on profits.

Several other question examine producers' attitudes about public issues. Most (79 percent) agreed that "Animal agriculture is being unfairly blamed as a cause of water pollution." Most (80 percent), however, feel that "Public concern over animal waste is really more about odor than about water quality." Producers do seem to accept some government intervention in that many (60 percent) disagreed that "Poultry growers should have the right to manage their poultry litter in any way they choose." Just one third agreed that "Taxpayers should help pay more for water pollution control on farms." Almost half (46 percent) agreed that "The new state regulations on animal waste are going to be impossible to enforce." Respondents were evenly divided in their agreement (51 percent) that "Environmental laws are getting so strict that many growers will have to quit raising poultry."

FUTURE DIRECTIONS

This paper has only presented an initial assessment of some data from this major survey. Further analysis remains to be done for the information collected from the poultry producers. It will also be important to compare their attitudes and behavior with that of the swine producers (n=400) and cattle producers (n=200) that were also included in the overall study. Results of this work should prove useful for shaping future directions of Extension educational programs, public policy evaluation, and technical research on waste management.

EFFECT OF STORAGE TIME ON STOCKPILED TURKEY LITTER NUTRIENT (MINERALS) PROFILE

Dr. Sheila E. Scheideler
Associate Professor, Extension Poultry Specialist
University of Nebraska
Department of Animal Science
Lincoln, NE. 68583-0908

A large turkey operation had stockpiled litter for the past 10 years in a field near their operation. It was estimated that the farm was producing approximately 20,000-30,000 tons of manure plus litter per year for their 200,000 bird/year operation. The disposal field was in close proximity to the Middle Loup River (within 400 yards) and on porous sandy soil. During the summer of 1992, a complaint was filed with the Nebraska Department of Environmental Quality (D.E.Q.) concerning the environmental risk of this stockpiled turkey litter and the D.E.Q. requested that the producer move all of the litter from that location by April, 1994. In September, 1992, the producer contacted the University of Nebraska Poultry Extension Office about this problem and requested assistance in determining the best utilization of the stockpiled litter. A field visit was conducted in October of 1992 to sample the stockpiled litter for determination of nutrient value. Litter samples were taken from the most recent pile (less than 1 year of age), and one of the approximately 5 year and 10 year old stock piles, respectively.

METHODS

A spade type shovel was utilized to take sample from the 3 different age stock piles (1, 5 and 10 years of age). Samples were composited from 3 different sites in the pile (front, middle and back) at 2 different depths into a 5 gallon bucket. Samples were mixed and then subsampled into approximated 5 lbs bags for transport to the University of further analysis. The samples were submitted to the University of Nebraska Soil Testing Laboratory for dry matter, mineral and N analysis according to the Recommended Chemical Soil Test Procedures for the North Central Region (1988).

RESULTS AND DISCUSSION

Samples were analyzed for moisture, N, NH4, Ca, P, K, Mg, Al, Si, P, Su, Cl, Mn, Fe, Cu, Zn and Mo at the soil testing laboratory. Results of the turkey litter analysis and reference reports of broiler litter analysis (Vandepopuliere et al., 1992) and broiler litter compost analysis (Mitchell and Brown, 1992) are shown in Table 1. Physical appearance of the 10 year old pile showed almost no feathers and a well decomposed type of product that many weeds were growing on.

Table 1. Nutrient Analysis of 1, 5, and 10 Year Old Stockpiled Turkey Litter, Broiler Litter[a] and Broiler Litter Compost[b]

Nutrient	1 Year Old Turkey Litter	5 Year Old Turkey Litter	10 Year Old Turkey Litter	Broiler Litter[a]	Broiler Litter Compost[b]
Moisture, %	54.4	22.8	31.3	27.15	38.5
Total N, %	2.73	2.3	1.62	5.32	1.88
NH4, ppm	4175	5054	10.1	1057	-
P, %	2.21	1.61	1.98	2.42	1.55
K, %	3.02	2.16	.96	1.9	1.72
Cl, %	.539	.451	.241	-	-
Ca, %	2.21	2.12	2.30	3.07	2.05
Mg, %	1.02	.97	.95	.7	.45
Al, %	.349	.367	.386	-	-
Si, %	2.26	2.49	2.62	-	-
S, %	.626	.489	.557	.49	-
Mn, ppm	305	247	348	451	515
Fe, ppm	1808	1325	1538	1020	5853
Cu, ppm	383	252	126	61	404
Zn, ppm	305	252	318	235	377
Mo, ppm	1.5	1.5	3.5	-	13

[a]Taken from Vandepopuliere, et al., 1992.
[b]Taken from Michell and Browne, 1992.

Results of the analysis indicated that there is considerable loss of moisture, N, P, K, Cl, Fe and Cu from the stockpiled turkey litter over the 10 year time period. Nitrogen was probably lost mostly in the ammonia form since 1/4 to 1/3 of the N in litter is usually ammonia N. The 10 year pile was pretty much devoid of any ammonia N, while the

1 and 5 year piles still had quite a bit present. It is likely possible that some anaerobic microbial action in the litter piles could continue to generate some ammonia N over time. Total N also decreased over the time period and at 10 years, was comparable to the broiler litter compost N values reported by Mitchell and Browne (1992). Phosphorus, potassium, chloride and copper decreased as the storage time increased. There were not great dietary requirement changes in these ingredients over the last 10 years, so the loss of these nutrients from the piles was likely due to runoff and leaching. Levels of Ca, Mg, Al, Si, S, Mn, Fe, and Zn did not change very much during the 10 year storage period. It may be that minerals that do not runoff or leach are more tightly bound to organic matter. The main concerns of runoff and leaching are the potential contamination of surface and ground waters. This should have been a concern for this operation since the Middle Loup River was within 400 yards of the stockpiles and a sandy soil with a high water table was the type of soil on which the litter was stored on.

EXTENSION RECOMMENDATIONS

As a result of the field visit and litter analysis the extension specialist suggested 2 alternative uses for the stockpiled turkey litter: 1. Use as a fertilizer on local meadow and crops land, and 2. Use as a feed supplement to wintering cowherd. Extension specialists in each of these areas (Soil Science/Agronomy and Beef Specialist) were contacted for specific recommendations to the turkey producer. The turkey producer choose to sell the litter to local crop producers within a 50 mile radius. It was also recommended that the producer work with the Extension Service, Soil Conservation Service and Department of Environmental Quality to design a more suitable storage area for stockpiled litter.

REFERENCES

Mitchell, C.C. and C.E. Browne, 1992. Plant nutrient availability in fresh and composted poultry wastes. Proc. National Poultry Waste Management Symposium, pp. 391-395.

Recommended Chemical Soil Test Procedures for the North Central Region, 1988. North Central Region Publication #221.

Vandepopuliere, J.M., J.J. Lyons and C.D. Fulhage, 1992. Broiler litter sampling reveals needed information. Poultry Digest p. 14-18.

THE ECONOMICS OF USING A BROILER-LITTER/GRAIN SUPPLEMENT FOR WINTER STOCKERS ON RYE COVER IN PEANUTS IN ALABAMA

Patricia A. Duffy*
Associate Professor

Gavin Nawrocki*
Research Assistant

David D. Kee**
Research Associate

James L. Novak*
Associate Professor

Depts. of Agricultural Economics* and Agronomy**
Auburn University, Al, 36849

Rye is often used as a cover crop for peanuts in Southeast Alabama. Hoping to recover some of the costs of planting the cover crop, many producers graze the rye. In this paper, we examine the economic potential for using a broiler-litter/grain supplement for steers grazed on rye cover. Broiler litter is a good source of protein, energy and minerals for stockers. It has an energy value similar to high quality hay (Fontenot, 1992; Gerkin, 1990; Ruffin and McCaskey, 1991). For stocker operations, litter is generally mixed about half and half with grain for a broiler-litter/grain supplement. Previous research has shown that copper toxicity is not a problem over limited time periods (Ruffin and McCaskey, 1991).

Animal weight gains are intrinsically tied to the availability of forage, and thus indirectly to stocking rate (Bransby, 1989). Stocking rate is a crucial determinant of net returns per acre (Bransby, 1989). Generally, increasing the stocking rate decreases available forage and thus decreases average daily gain (ADG) per animal. Feed supplementation can overcome limitations due to low forage availability, increasing carrying capacity of a pasture and possibly generating higher economic returns.

Use of supplement and higher stocking rates per acre may allow producers to recoup more of the costs of the rye cover crop. Increased producer awareness of the potential gains from use of supplementation should lead to higher use of broiler litter as a feed substance, reducing waste management problems associated with the poultry industry in this area of Alabama.

EXPERIMENT DESIGN

The experiment site, a Dothan series soil (fine, loamy, siliceous, thermic Plinthic Kandiudult) was fertilized with a balanced fertilizer at a rate of 60-60-60 lbs. NPK/acre, tilled and cultipacked in early October of each year. "Wintergrazer-77" rye (*Secale cereale* L.) was then drilled into the clean, firm seedbed at a rate of 90 lbs. seed/acre. Each paddock area was then fenced using portable electric fencing. The stocking rate desired for each treatment was attained by varying the paddock size allocated for six steers per treatment (Table 1).

Six steers, selected from fall purchased animals, were randomly allocated to each treatment. In the first year, grazing started on 12/16/86 and continued for 112 days (4/7/87). Grazing in the second year started on 12/29/87, continued for 100 days until 4/7/88. Average grazing time across the two years was thus 106 days. Mean beginning steer weight was 480 lbs. in 1986-87 and 509 lbs. in 1987-88. Steers were weighed, unshrunk, to monitor animal health and treatment differences.

Animals in the supplemented treatment received a ration consisting of 41% poultry litter/49% grain sorghum/5% peanut hay/5% molasses. Pre-weighed supplement was provided daily with the remnants for the previous feeding being removed, weighed and discarded. Supplement intake per pen was determined by subtracting the remnant weight from the amount fed.

Table 1. Treatment description

Treatment Number	Stocking Rate (# head/ac)	Supplement Intake
1	1.25	None
2	1.25	*ad libitum*
3	2.00	*ad libitum*
4	2.75	*ad libitum*
5	3.50	*ad libitum*
6	4.25	*ad libitum*

ANALYSIS

Mean average daily gain (ADG) for each treatment, averaged over the two years, is reported in table 2. Significant differences in means were tested using Fisher's Least Significant Difference test. Results were averaged across years because no significant interactions with year were found using SAS's general linear model (GLM) procedure with contrast statements.

As shown in table 2, the mean ADG (2.84 lb/day) is highest for animals stocked at 1.25 head/ac and fed the ad libitum supplement. This mean is not significantly different from the mean ADG for animals stocked at 1.25 head/ac without supplement (2.69 lb/day) or for those stocked at 2 head/ac with supplement. At higher stocking rates, significant reductions in ADG are found.

Table 2. Mean ADG response to year and treatment. Means with the same letter are not significantly different

Grouping		Mean	Treatment
	A	2.69	1
	A	2.84	2
B	A	2.53	3
B	C	2.25	4
B	C	2.20	5
	C	1.96	6

Although the highest ADGs are found with a stocking rate of 1.25 head/ac and supplementation with broiler-litter/grain combination, this production strategy may not be economically optimal. To determine the best production strategy from an economic standpoint, enterprize budgeting is used. The goal of most producers is to maximize profit, subject to whatever limiting factors might exist. For most producers, acreage available for grazing is the most limited resource. If this is the case, maximizing net returns per acre will result in the highest total profits.

Cattle prices vary seasonally and also with the weight of the animals. Since buying time is relatively fixed and because selling price is affected by time spent on pasture, different equations for buying and selling prices were estimated:

$$P_0 = a - bW_0 - cGrade \qquad [1]$$

$$P_t = a' - b'W_t - c'Days - dGrade \qquad [2]$$

where P_0 is the buying price; P_t is the selling price; Days is the number of days an animal has spent on pasture between the buying and selling period; W_0 is the initial weight; and W_t is the weight at selling time such that $W_t = W_0 + \Delta W$ with ΔW being the total gain between buying and selling time or time the animal is taken off grazing. For estimation purposes, Grade was treated as a 0-1 indicator variable with value 0 for number 1 grade and value 1 for number 2 grade.

The buying price equation was estimated using weekly Alabama data from 1986 to 1989 for the last week of November for three different weight classes (250-350, 350-450, 450-550 lb) and two different grades, number 1 and number 2. The selling price equation was obtained using weekly Alabama data from 1987 to 1990 for the months of March and April (selling time), two different weight classes (550-650, 650-750) and the two grades used above. Price data were obtained from USDA livestock market publications. All prices were normalized to constant 1990 dollars using the producer price index. Both equations were corrected for autocorrelation.

Results for the price regressions are shown in table 3. As ending weight increases, selling price decreases (Table 3). Thus, a price premium is associated with low ending weights. Here, cattle were assumed sold on April 7th, after an average of 106 days on pasture. Cattle are sold early to allow timely peanut planting. No grade data were recorded for the experiment. Cattle were therefore assumed to be evenly mixed between grades 1 and 2.

Table 3. Regression analysis of buying and selling prices as a function of animal weight grade, and days on pasture

	Buying Price	Selling Price
Intercept	157.83000[a] (12.2200)	149.07000[a] (9.8890)
Weight	−0.11789[a] (0.28892)	−0.0086794[a] (0.013896)
Grade	−16.865[a] (2.6544)	−8.5808[a] (0.31096)
Days	−0.043953[b] (0.021930)	
R^2	0.6701	0.8200

[a]Indicates significance at the .01 level of confidence.
[b]Indicates significance at the .05 level of confidence.
Numbers in parentheses are standard errors of the estimates.

Enterprise budgets were constructed for each treatment. Beginning weight was assumed to be 506.5 lbs. Ending weights were determined using the ADGs from the experiment. Buying and selling prices were computed using equations (1) and (2). Variable and fixed costs of production were obtained from Alabama Cooperative Extension Service (ACES) budgets. Because of space limitations, full budgets cannot be presented for each of the six grazing options. Net budgeted returns over costs for each option are summarized in table 4. An example of a full enterprise budget is provided in Appendix table 1.

Table 4. Stocking rate, supplement, selling price, and net returns

Stocking rate	Supplement (lbs./head)	Selling price	Returns over variable costs per acre	Returns over fixed costs per acre
1.25	0	0.71	28.49	−26.12
1.25	797.83	0.69	4.67	−49.94
2.00	587.58	0.72	55.39	0.78
2.75	1294.92	0.75	38.03	−16.58
3.50	1779.58	0.75	9.98	−44.63
4.25	1877.45	0.77	−20.96	−76.00

As can be seen, highest returns per acre occur at a stocking rate of 2.00 animals per acre, using the broiler-litter/grain supplement. Returns over variable costs are nearly twice as high as those that would be obtained using a "traditional" grazing rate of 1.25 animals per acre without supplement. More importantly, use of broiler-litter allows the farmer to recover all costs of producing rye cover, including a $25.00 return to the land resource. As an added benefit, use of broiler litter should reduce fertilizer costs from those budgeted, resulting in even greater profits. The wide-scale adoption of higher stocking rates would also lead to increased demand for poultry litter as a feed resource, reducing waste disposal problems in the area.

REFERENCES

Bransby, D.I. 1989. Justification for grazing intensity experiments: economic analysis. J. Range Mgmt. 42:425-430.

Fontenot, J.P. 1982. Assessing animal-waste feeding: Nutritional guidelines and safety considerations. Anim. Nutr. and Health. 36:12-15.

Gerkin, J. 1990. Utilization of poultry waste by feeding cattle. *In* J.P. Blake and R.M. Hulet (eds.) 1990 National Poultry Waste Symposium. Auburn, Al.

Ruffin, B.G. and T.A. McCaskey. 1991. Feeding broiler litter to beef cattle. Alabama Coop. Ext. Service. Circ. ANR-557.

CONSTRUCTION COST AND OPERATING CHARACTERISTICS OF ALTERNATIVE DESIGNS FOR BROILER MANURE STORAGE STRUCTURES

George W. Malone and Nick Gedamu
Associate Scientist and Research Associate I
Research and Education Center
University of Delaware
Georgetown, DE 19947

James N. Scarborough
Associate Professor
Department of Agricultural Engineering
University of Delaware
Newark, DE 19717

Ron F. Gronwald
State Conservation Engineer
Soil Conservation Service
Dover, DE 19901

Currently the Soil Conservation Service (SCS) approved broiler manure storage structure for Delmarva, wooden sidewalls and metal roof, is expensive and most are designed to provide only limited storage capacity. The cost is $12,000 to $15,000 for a 50,000 bird operation, and provides storage only for cake removal and one brood chamber clean-out over a 12-month period. When a total clean-out occurs, typically every two to three years, manure must be either spread immediately or stored in open piles. In addition, many operations lack sufficient acreage to fully utilize the manure produced and often depend on local farmers to remove the manure from the site during or immediately following cake removal or a total clean-out. A final concern is spontaneous combustion in the stored manure. A 1991 survey (Scarborough and Scarborough, 1992) revealed 8.8% of these wooden structures had one or more structural fires and another 15% had experienced excessive manure heating during storage.

The objective of this study was to investigate noncombustible and low-cost, environmentally sound alternative broiler manure storage structure designs. Cost, simplicity of construction and operation, and effect on manure composition for three designs were evaluated.

MATERIALS AND METHODS

Descriptions of Structures

A control (C), open stacking of broiler manure on barren soil, was compared to a noncombustible roofed structure (RS), a bunker structure (BS), and a holding pad (HP)(Figure 1). Each structure was 12 ft wide by 24 ft long, and there was 30 ft between each unit. The structures were of sufficient size to duplicate commercial loading and unloading practices. The vegetative cover (grass) was stripped from the site and compacted fill was added accordingly to provide the same finished floor grade for all units.

The noncombustible RS was designed as an alternative to the conventional wooden roofed storage structure. The floor consisted of 4 inch thick soil cement, a mixture of cement and sand that was spread, leveled, compacted, and then saturated with water. The 4 ft high precast concrete wafer walls were set on the pad and a sill plate with roof base connector was attached on top. The roof was 22 gauge galvanized metal (Galvalume™).

The BS is a SCS approved structure for Delaware which is a lower cost alternative. One-half of the floor had a permeable filter fabric liner and the other half had 6 mil polyethylene; both were covered with 12 inches of a compacted fill. The 5 ft high side and backwalls were constructed of salt-treated lumber. A tarpaulin was used to cover the structure. PVC pipe was inserted into a hem on the tarp's edges and rubber straps secured the PVC pipe on the tarp to a metal pipe anchored to the bunker sidewall. A rounded sill plate attached to the top of the bunker walls prevented tarp damage at the walls. Used tires were placed on the manure pile prior to covering with the tarp to aid in shedding rainwater off the top of the structure.

Two types of flooring material were used for the HP. Soil cement, the same as used in the RS, was placed in one-half of the unit while the other half received a wet soil cement pre-mixture which was flowable and self-leveling. Thickness of the floor varied from 6 inches at the entrance to 4 inches at the back-half of the structure. The floor was sloped to prevent runoff. Both soil cement mixtures were formulated to have a compressive strength of 300 psi. No impervious-type liners (i.e. polyethylene) were used. Both 2.7 ft high single-faced highway barriers and 2 ft high soil cement blocks were used for the walls (cost and wall stability were similar for both types). The 3 ft high backwall was constructed of salt-treated lumber.

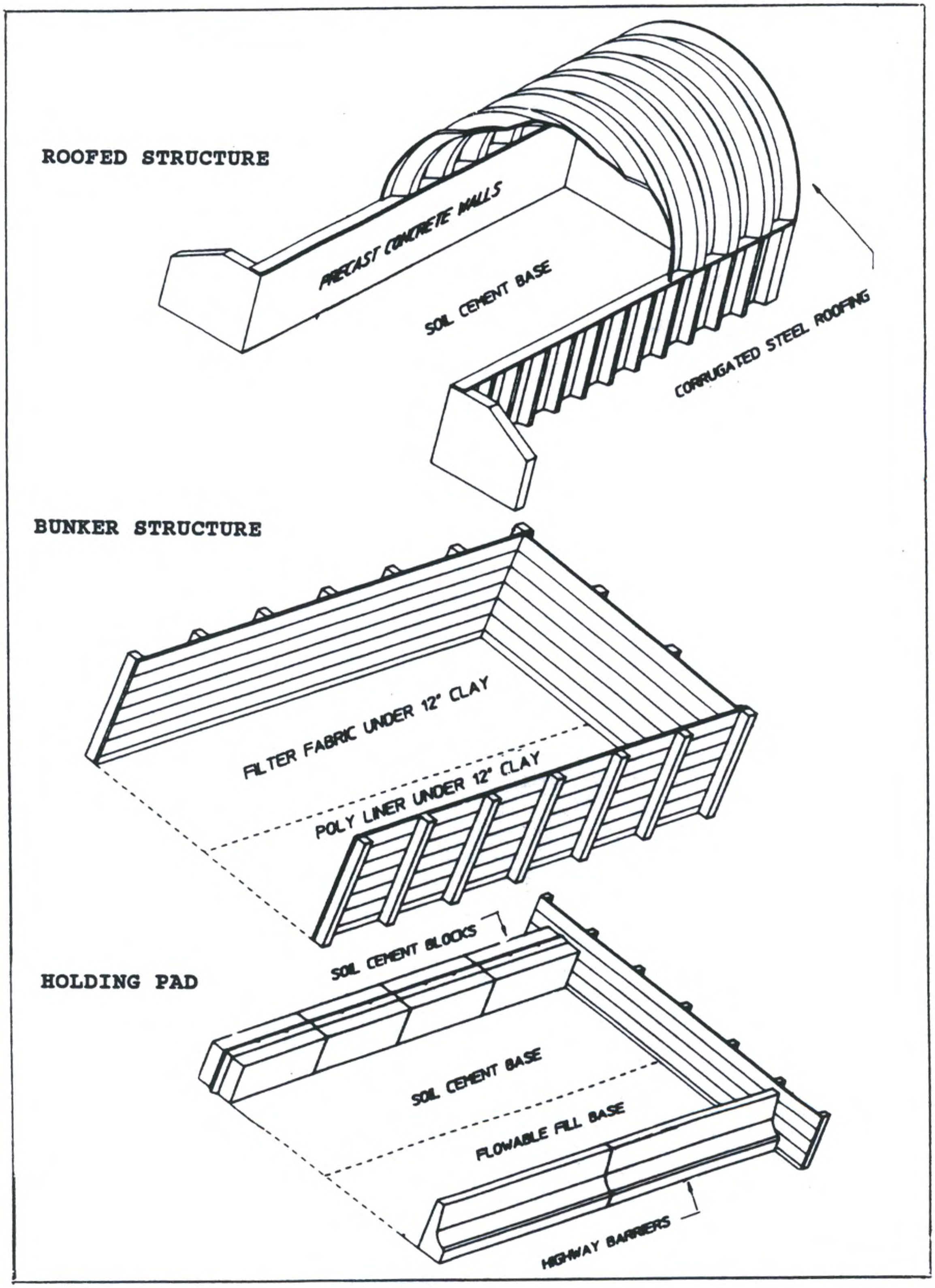


Figure 1. Alternative Designs For Broiler Manure Storage Structures

Loading and Sampling

The structures were filled with manure and emptied twice over a 7-month (July to February) evaluation period. On an interval of approximately every 35 days, the structures were filled half-full, filled completely, held full, held emptied, and the cycle repeated again. Clean-out and cake manure types were used for the first and second loading cycles, respectively. Manure spreaders and dump trucks were used to load the structures for each cycle. Approximately 16 tons of manure were added per structure per loading period. For each loading, all manure was obtained from a common source. It was weighed with truck scales, and sampled upon placement and removal from each structure. A pooled sample of the manure from each structure was analyzed (Standard Methods, 1985) for moisture, ash, total Kjeldahl nitrogen, and inorganic nitrogen (nitrite-N plus nitrate-N and ammonium-N). It is important to note the experimental units (structures) were not replicated. Therefore, results can only be discussed in general terms.

RESULTS AND DISCUSSION

Construction

Labor required to construct the RS was nearly twice that of the BS or HP. Greater expertise with construction of these facilities, particularly the RS, and other minor modifications could be implemented to improve construction efficiency and reduce the cost of these structures. For a full-sized structure of equal storage capacity (volume), the ESTIMATED cost of the RS, BS and HP is +12%, -45% and -82%, respectively, of a current SCS approved roofed storage structure ($.85/ft^3) for Delmarva. Based on these estimates, the cost of a conventional roofed structure to serve a typical farm with 50,000 bird capacity would be $15,000 compared to $16,800, $8,250 and $2,700 for the RS, BS and HP, respectively. On a floor area basis, the RS cost 32% more than a conventional structure. However, with the current recommendations not to stockpile manure against the wooden sidewall due to spontaneous combustion concerns, storage capacity is reduced with the conventional roofed structure but not with the RS.

Operational Characteristics

Labor required to operate the RS and HP was equal. During the 7-month evaluation period, the BS required an additional 1.5 hours to remove and replace the tarp and tires. Tarp replacement was more difficult under windy conditions, often requiring two people. Yet, wind did not effect the tarp or its performance once in place. The control required up to twice the time for the loader to remove the manure due to soft, often damp soil conditions, and the lack of side and end-retaining walls to confine the manure. Visual observations of the soil cement flooring suggest the dry pre-mix was more durable and stronger than the wet, flowable fill mixture. By the end of the 7-month evaluation period, weathering (freeze/thaw) appeared to weaken the surface structural integrity of the flowable fill floor. Weight of tractors, spreaders, loaders, and dump trucks on each of these low-strength floors did not result in cracking.

Manure Composition

The manure piles for all storage methods were "crowned" with a loader following dumping to eliminate pockets for water accumulation (uncovered HP and C) and to maximize storage volume. Observed changes in weight of manure during storage are summarized in Table 1. Moisture loss from evaporation and decomposition may have contributed to the net weight loss of manure during storage with the RS. Reasons for the increase in weight with the BS during Period 2 are unclear. With the uncovered treatments (HP and C), wetting of the manure with rainfall contributed to the higher manure weight after storage. Manure in the HP had consistently greater net weight gain with wetness observed at the surface and edges (next to walls). The weight of the manure taken from the open stockpile (C) after storage averaged 15% more than that originally placed in storage. With both uncovered treatments, there was a 4 to 6 inch moist/wet layer on top of the manure at the first unloading and almost complete moisture saturation at the second unloading. Differences in manure type, season, and precipitation between the periods may be factors contributing to these changes in manure weight during storage.

Table 1. Effect of Storage Structure on Changes in Manure Weight During Storage[a]

Storage Structure	Period 1			Period 2			Average
	In	Out	(%)	In	Out	(%)	(%)
Roof	14.0	13.2	(-5)	15.6	14.3	(-8)	(-7)
Bunker	15.5	14.9	(-4)	18.3	17.8	(+3)	(-1)
Holding Pad	13.9	14.6	(+5)	17.1	18.6	(+9)	(+7)
Control	15.9	17.9	(+13)	17.5	20.4	(+17)	(+15)

[a]Tons

Composition of the "uniform" manure placed in storage and that removed was highly variable. In the uncovered piles, obtaining a representative sample from manure having wet and dry zones was difficult. Each structure was loaded in two stages, contributing to spacial variability. Manure moisture contents of the HP and C manure increased 19% and 42%, respectively, and were consistent with changes in weight during storage. Changes in ash and the nitrogen components of the manure during storage were highly variable. Sims (1983) found covering manure stockpiles with polyethylene had little influence on nitrogen conservation when expressed on a dry-weight basis. The primary advantages of covering are less odor, improved handling characteristics, and less transportation cost associated with the decrease in water content.

SUMMARY

Results of this nonreplicated demonstration suggest all three alternative manure storage designs were generally satisfactory from a structural and functional standpoint. The covered structures (RS and BS) may be more desirable for long-term storage since they maintain desirable manure handling characteristics (constant or reduced moisture levels). For short-term storage, the HP may be adequate since water uptake from precipitation was minimal (7% weight increase). The effect of storage method on manure nitrogen content was variable and appeared to have little influence during this short-term study. The individual farm circumstances will determine the storage method most appropriate.

REFERENCES

Scarborough, J.N., and R.W. Scarborough, 1992. Summary of the fire hazard questionnaire for poultry manure storage structures in the State of Delaware. Technical Report submitted to the Delaware Soil Conservation Service.

Sims, J.T., 1983. The effect of stockpiling practices on the fertilizer value of poultry manure. Technical Report submitted to Delmarva Poultry Industry, Inc.

Standard Methods for the Examination of Water and Wastewater. 1985. 15th Edition. American Public Health Association, American Water Works Association, Washington, D.C.

AN ECONOMIC EVALUATION OF DEAD-BIRD DISPOSAL SYSTEMS

J. R. Crews
Associate Professor
Department of Agricultural Economics and Rural Sociology

J. P. Blake
Associate Professor
Department of Poultry Science

J. O. Donald
Professor
Department of Agricultural Engineering
Auburn University, Alabama 36849

Individual poultry producers and the U.S. industry collectively are fully aware that dead-bird/waste management is a continuous and growing challenge. With the large volume and concentration of on-farm wastes being produced, coupled with the intensification of environmental awareness, acceptable methods of handling dead-bird disposal are being closely examined by producers and scientists alike. If being biologically and environmentally sound, then economics and resource factors should surface as key variables in the determination of which method would be best-suited for a producer's operation.

OBJECTIVES

The focus of this study was to economically evaluate alternative disposal methods in terms of net annualized costs. The methods considered were those technologies that currently are being used in the industry (disposal pits, large-bin composting and incineration) and also on examination of emerging technologies, those that are currently being "field-tested", was conducted. The effectiveness and limitations of these methods have been investigated by many (Murphy and Handwerker, 1988; Donald and Blake, 1993; Pose, 1990; Blake and Donald, 1992; Donald and Blake, 1992).

METHOD OF EVALUATION

Each method was evaluated in terms of the net annualized cost per unit of carcass disposed. This approach takes into account the initial investment costs, annual operating (variable or cash) costs, annual fixed costs (interest on investment, depreciation, etc.), value of by-product and results in an annualized net cost of disposing of mortalities. Three flock sizes (40,000; 100,000; and 200,000) were examined to measure sensitivity of economies of size among systems.

RESULTS

Existing Technologies

As shown in Table 1, among those methods labeled as "existing technologies", for a flock size of 100,000 birds, the disposal pit had the lowest investment costs ($4,500) followed closely by incinerator ($2,000) and then large-bin composting ($7,500, not inclusive of front-end loader and spreader required for composting and distribution). Annual variable costs estimates were highest for incinerator (mainly because of fuel), followed by large-bin composting and lastly, disposal pit. When total annual costs (both fixed and variable) were assessed, incinerator was highest, followed closely by large-bin composting and then disposal pit. After accounting for the value of by-products, the net annualized cost for large-bin composting dropped significantly, to 4.88 cents per pound, compared to incineration at 8.92 cents. Of the three methods, the disposal pit had the lowest net cost at 3.68 cents per pound of carcass disposed.

Emerging Technologies

As for "emerging technologies", small-bin composting (which utilizes the same concept as large-bin, except the bin size and process trades off machinery requirements for labor, i.e. lower investment costs) had the lowest net cost of 3.50 cents per pound of carcass. For fermentation and refrigeration, both considered intermediate rendering processes, the investment costs were relatively high. While variable costs were moderate for fermentation, they were highest for refrigeration, due mainly to electricity requirements. After valuing the by-product, the net annualized costs per pound for fermentation and refrigeration were 4.55 and 11.41 cents, respectively.

Table 1. Economic analyses (net annualized cost) of various dead-bird disposal systems for a flock size of 100,000 birds(a)

Item	Existing Technologies: Disposal pit	Existing Technologies: Large-bin compost	Existing Technologies: Inciner-tion	Emerging Technologies: Small-bin compost	Emerging Technologies: Fermen-tation	Emerging Technologies: Refri-geration
	dollars					
Initial investment cost	4500	7500	2000	2016	8200	14500
Annual variable cost	1378	3281	4833	3661	2862	5378
Annual fixed cost	829	1658	522	297	1190	2670
Total cost	2207	4939	5355	3959	4052	8048
Value of by-product	0	2010	0	1860	1320	1200
Net annualized cost	2207	2929	5355	2099	2732	6848
Cost per hundredweight of carcass disposed	3.68	4.88	8.92	3.50	4.55	11.41

(a) Key production and financial assumptions:

Average weight of carcass (lbs.) --------->	2.00	Mortality (percent) ------>	5.00
Length of grow-out cycle (days) ---------->	45.00	Flocks/batches per year -->	6.00
Cost of compost removal ($/ton) ---------->	7.00	Labor rate ($/hr.) -------->	5.00
Value of straw ($/ton) ------------------>	60.00	Fuel/butane ($/gal.) ----->	.62
Value of litter ($/ton) ----------------->	20.00	Tractor fuel ($/gal.) ---->	.83
Value of compost by-product ($/ton) ------>	20.00	Cost of electricity ($/kwh.)	.08
Value of fermented by-product ($/lb.) --->	.02	Cost of carbohydrate ($/lb.)	.07
Value of refrigerated by-product ($/lb.) ->	.02		

Economies of Size

An analysis was also made for smaller (40,000) and larger (200,000) flock sizes. Figure 1 illustrates the impact operational size has on net costs for "existing technologies" disposal methods. Comparing flock sizes of 40 and 200 thousand, the system yielding the greatest reduction in costs (over 50%) was large-bin composting. Disposal pit was the least responsive at 26% followed closely by incineration at 30% reduction in net annualized costs. However, the order of rank remained the same as with the 100,000 flock size. Figure 2 depicts the same type size comparison for those disposal methods categorized as "emerging technologies". Fermentation was the most sensitive to cost reduction as flock size increased. Going from a flock size of 40,000 to 200,000, fermentation exhibited a net annualized reduction in cost of 60 percent, from 8.57 cents to 3.40 cents per pound of carcass disposed. Small-bin composting showed a respectable decrease of 28% while refrigeration resulted in a modest reduction of only 11 percent.

CONCLUSIONS

The management of poultry operations has become increasingly complex with the increasing emphasis on proper methods of bird mortality disposal. The method selected by producers should meet biological, environmental and economical criteria. Producer evaluations must take into account their own set of resources and limiting constraints.

There is no single method of dead-bird disposal that comes out the "clear winner" when subjected to major types of scrutiny, namely; biological, environmental (regulatory) and economic. Disposal pits are economically attractive but due to regulatory constraints, may not be an option in many locations. Incinerators are biologically efficient, but are energy intensive and maybe more importantly, are being viewed by many as nuisances due to air pollution. Large-bin composting is a proven, on-farm method to dispose of mortalities at moderate costs. Land and management resources are critical elements in obtaining a biosecure product that can be that properly utilized.

Small-bin composting could be an attractive alternative to producers that do not have the necessary equipment (loaders and spreaders) to handle larger volumes of waste. The dependency of manual labor (verses machinery) will set limits as to the size of operation this method would be applicable. Fermentation could be a feasible alternative for some growers. It will likely be large growers (over

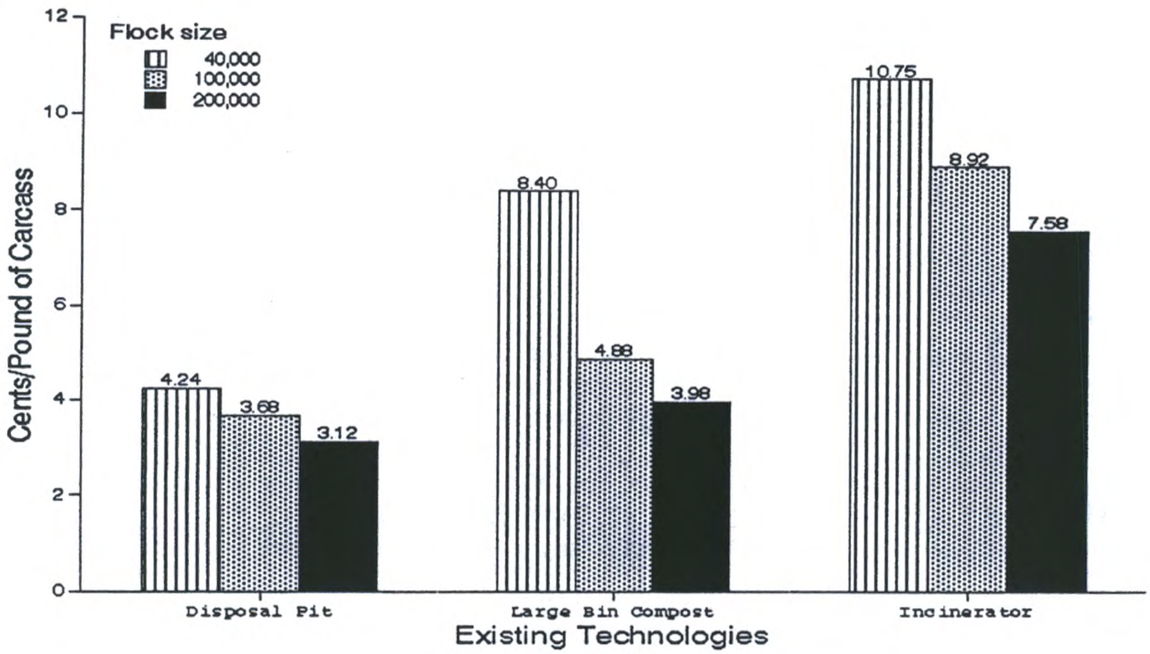


Figure 2. Net Annualized Cost Analysis of Dead Bird Disposal Systems

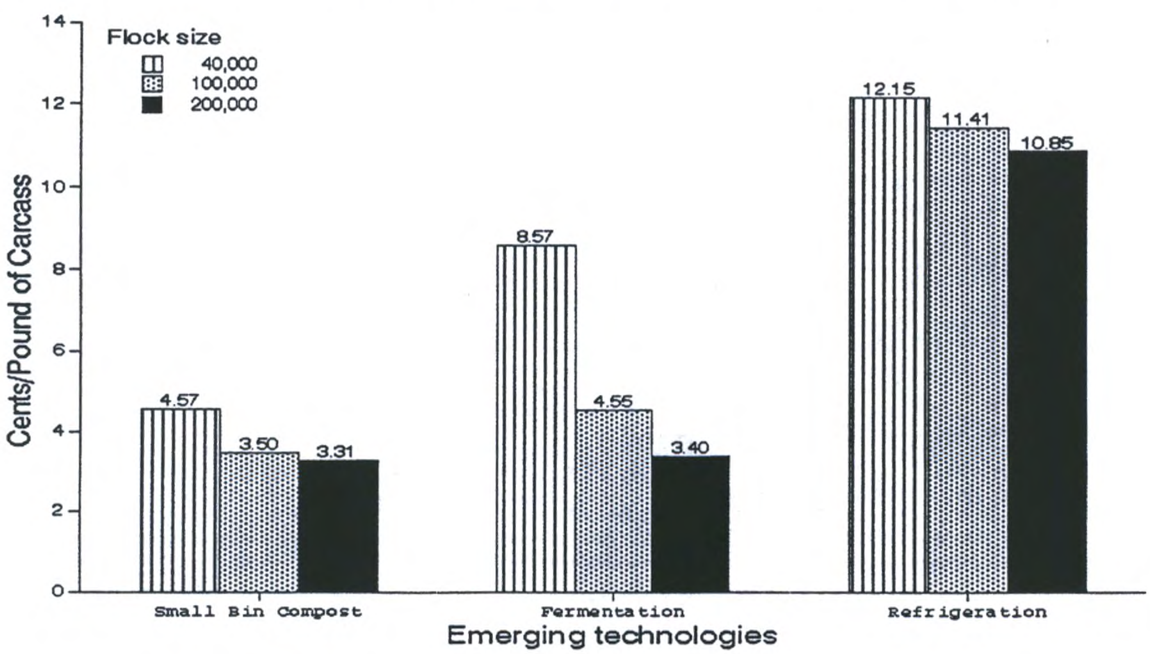


Figure 1. Net Annualized Cost Analysis of Dead Bird Disposal Systems

200,000 in flock size) or possibly a situation where a central unit could be designed to serve several producers in close proximity. Refrigeration is a biologically and environmentally effective method, but is expensive in both investment and operating costs. The key element for both fermentation and refrigeration is the existence of a rendering facility to accept and/or pay for the by-product. Because of this, adoption of these technologies will have geographical constraints. Further, the value of the by-product could fluctuate due to sensitivity of competing protein sources, e.g. soybean meal, for use as a feed ingredient.

If a given technology meets the biological and environmental criteria, then managerial and economic considerations should be paramount in selecting a disposal method. All of the methods examined had tradeoffs in terms of resource requirements such as investment and operating costs, labor, managerial expertise and size of operation. These proven and potential technologies should be closely examined to insure biological, environmental and economical compatibility.

REFERENCES

Blake, J.P. and J.O. Donald, 1992. Poultry Science, 71(1):21.

Donald, J.O. and J.P. Blake, 1993. Extension Circular ANR-804, Alabama Cooperative Extension Service, Auburn University, AL.

Donald, J.O. and J.P. Blake, 1992. In: Proceedings of the 1992 National Poultry Waste Management Symposium, pp. 56-63, Auburn University, AL.

Murphy, D.W. and T.S. Handwerker, 1998. In: Proceedings of the National Poultry Waste Management Symposium, pp. 65-72, Columbus, OH.

Poss, P.E., 1990. In: Proceedings of the 1990 National Poultry Waste Management Symposium, pp. 75-76, Auburn University, AL.

CHARACTERIZATION OF WASTEWATER FROM A SHELL EGG PROCESSING PLANT

P.A. Curtis and R.E. Carawan
Department of Food Science

K.E. Anderson and F.T. Jones
Department of Poultry Science

North Carolina State University
Box 7624
Raleigh, NC 27695-7624

Every year egg processing plants discharge an estimate 200 million gallons of wastewater. As the industry continues to grow and as food safety concerns increase, so will the volume of water used, the amount of wastewater discharged and the waste load. At the same time, processors will face increasing water costs, rising sewer charges, and tighter restrictions on waste load parameters such as BOD_5. Some plants will be faced with the possibility of a shutdown if they cannot meet legal restrictions, cope with limited water supply, or meet increased costs for water and sewer service.

Whenever eggs or food, in any form, is handled, processed, packaged and stored, there will always be an inherent generation of waste water. The quantity of this processing waste water and its general quality (i.e. pollutant strength, nature of constituents) have both economic and environmental consequences with respect to treatability and disposal.

Research has indicated that about 3 to 6 percent of the shell eggs entering egg grading plants are broken during processing (Miller and Mellor, 1971; Morris *et al.*, 1972; Shupe *et al.*, 1972). Much of the liquid egg contents and shell find its way into the wash water and, in turn, into the waste stream. Thus, the waste water from egg processing plants has the potential to create a high level of pollution. However, few research data are available on waste loads from shell egg processing plants. Hamm *et al.* (1974) reported median waste concentrations for wash waters in shell egg grading plants as follows: Chemical Oxygen

Demand (COD) 7,300 mg./l; total solids 9,300 mg./l.; volatile solids 4,600 mg./l. Carawan *et al*. (1979) reported a decrease on COD from 11,902 mg/l to 5,005 mg/l after modifications in one egg breaking test plant.

Alkaline cleaning formulations are designed to give an initial pH of near 11 in the wash water and wash water pH during operation is usually in the range 10 to 11 which is unfavorable for growth of most bacteria (Moates, 1978). Two Canadian researchers, Holley and Proulx (1986), evaluated the effect of wash water pH at moderate temperatures on *Salmonella* survival and found that *Salmonella* endured temperature of 38 and 42°C when washwater pH was ≤9.5. This finding agreed with previous research which indicated that *Salmonella* was more sensitivity to heat at alkaline pH's (Anellis *et al*., 1954; Cotterill, 1968). Furthermore, Kinner and Moats (1981) found that when wash water pH's increase from neutral to 10 or 11, bacterial counts always decreased regardless of water temperature. They also reported that as temperature increase from room temperature to 50 or 55°C, bacterial counts decreased regardless of pH. Laird *et al*. (1991) indicated that current processing practices are not sufficient to prevent the potential contamination of washed eggs with *Listeria monocytogenes*. Their study has shown that *Listeria* is readily isolated from the egg washing station environment, including wash water.

The Food Production and Inspection (FPI) Branch of Agriculture Canada routinely monitors egg grading stations in Canada to ensure that egg washing guidelines are followed. These guidelines include: 1) the maintenance of wash water at a temperature of 43±3°C; 2) the maintenance of wash water at pH≥10; 3) the maintenance and routine cleaning of washers and their parts (e.g., brushes and rollers); and 4) a complete change of wash water and cleaning of holding tank every 2 to 4 hours (FPI, 1983). These guidelines were developed in an attempt to eliminate pathogens that may be present in the wash water and to minimize microbial contamination of the washed eggs. At present, bacterial numbers in egg wash water are monitored to ensure that adequate sanitation is achieved. Total viable counts $>10^5$ cfu/ml are considered unacceptable (Bartlett *et al*., 1993). The U.S. currently only has regulations regarding wash water temperature and time between water changes in the tank.

The objective of this research was to characterize the waste load being produced by shell egg processing plants.

PROCEDURES

A large commercial egg processing plant was selected to participate in this project. Samples were taken from the plant on three different occasions. Two of the sampling times were winter months and one was summer.

Determinations were made of level for water use, biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), fats, oils and grease (FOG), total solids (TS), total dissolved solids (TDS), total suspended solids (TSS), total volatile solids (TVS), microbial load and pH in wash water tank(s) over a day's production. BOD_5, COD, FOG, TS, TDS, TSS AND TVS were determined as described in the Standard Methods for the Examination of Water and Wastewater (1992). Determine total plate count and coliforms in wash water using an AOAC approved method.

The monitoring of water usage at plant locations that produce high waste loads is essential to reducing water and sewage costs. With continuous monitoring and water quality evaluation at key plant locations, water usage and wastewater loads can be minimized.

RESULTS AND DISCUSSION

Every drop of water that goes down the drain becomes waste water that must be treated. Therefore, water conservation plays an important role in reducing processing waste. The average water use per dozen of eggs processed at the test plant was 0.15 liters. This is identical to the figure reported in the 1975 national survey for shell egg grading plants.

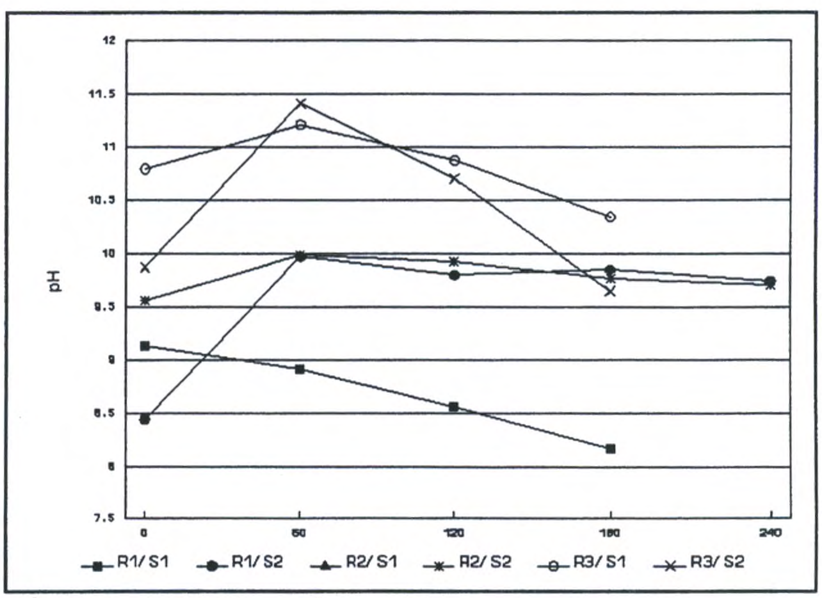


Figure 1 Wash water pH

Several previous research studies have determined that a pH of 10-11 or above is necessary to control bacteria. Indeed, pH is a relatively inexpensive to monitor and has been shown to offer significant protection against such bacteria a *Salmonella enteritidis*. However, most shell egg processors have no idea as to the pH of their wash water. Those processors who do monitor appear to do so only at the beginning of a processing run and intitial pH's are not maintained through the run. Furthermore, the recycling wash water, overflow losses and added water mean that pH is not always maintained. During the first two trials, pH in the wash tank was never above 10, but during the last trial (R3/S1 and R3/S2 in Figure 1) pH was maintain at ≥10. This alkaline pH appeared to affect several other waste water characteristics. Detergents are the means by which the pH wash water is elevated. However, detergent is, for the most part, dispensed in concentrations necessary to clean the egg shell and minimal thought is given to maintaining a pH of ≥10. Maintaining a pH level in a dual tank wash system has additional problems.

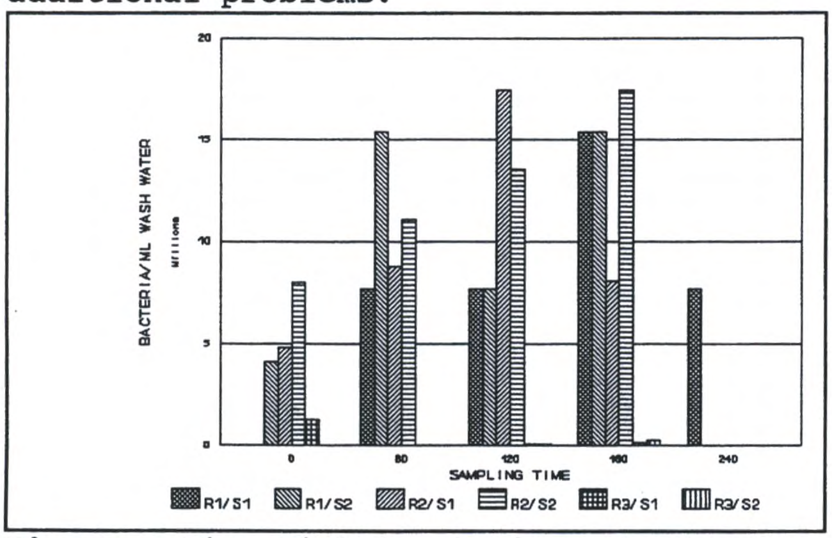


Figure 2 Microbial Levels in Washwater

This study, as well as previous studies, show that bacterial levels in wash water are affected by pH. When pH levels are maintained above pH 10 bacterial loads are greatly decreased (Figure 2). The bacterial levels shown in Figure 2 are for total plate count. Coliforms were also measured and had a similar notable decrease in the third trial.

Since the number of eggs processed by shift and by sampling date the variables used to characterize the waste load were expressed on a per dozen eggs processed basis. Table 1 provides the average values for each of the variables measured and a comparison of that value with research cited. Note the difference between the mg/dozen column and the mg/liter column. The authors believe that mg/dozen is a better basis for comparison, especially between plants, because of the difference the number of eggs processed in each plant. However, only mg/liter values are available in the literature.

Table 1. Wastewater Characteristics

VARIABLE	PROJECT (MG/DOZ)	PROJECT (MG/LITER)	RESEARCH CITED (MG/LITER)
FOG	18.76	93.17	NOT AVAILABLE
COD	1491.83	10586.67	7300
BOD_5	854.03	6038.33	NOT AVAILABLE
TS	1045.30	7632.33	9300
TSS	158.80	1013.33	NOT AVAILABLE
TDS	549.94	4090.05	NOT AVAILABLE
TVSS	117.48	696.67	NOT AVAILABLE
TVS	434.27	3065	4600

BOD_5 from of wash water from food plants is directly related to amount of the food in the waste load. In fact, BOD_5 can be estimated in food plant waste waters by estimating the fat, protein and carbohydrates in a particular wastewater and using the following factors:

Food Component	lbs BOD_5/lb Food Component
Carbohydrate	0.65
Fats	0.89
Protein	1.03

When these relationships are applied to eggs, we find that the estimated BOD_5 for whole eggs is 0.24 pounds BOD_5 per pound of product. If we were to discharge 66,459 lbs of BOD_5 in a month, (66459/0.24=276 912) our calculation would reveal that we lost 276,912 pounds of eggs.

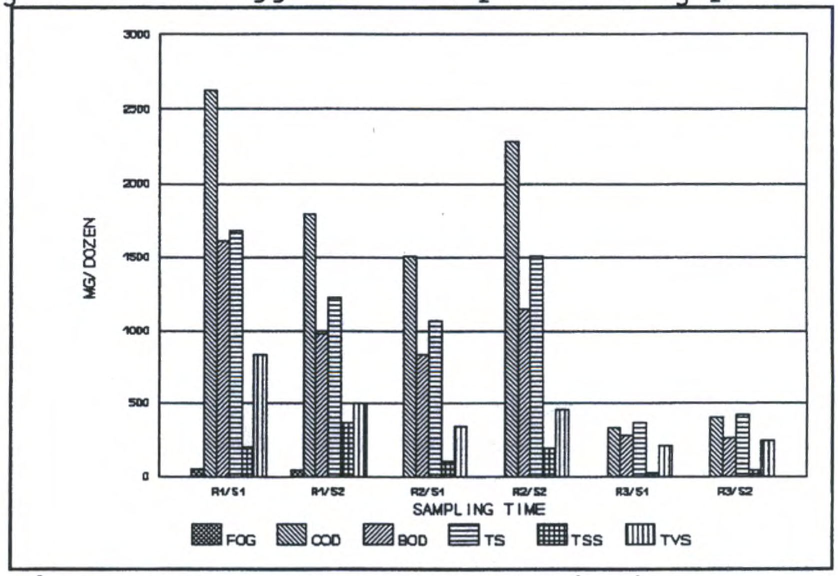


Figure 3 Wastewater Characteristics

Variables other than microbial load appear to be affected by the pH level. During trial three (R3/S1 and R3/S2, Figure 3) the wash water pH level three (R3/S1 and R3/S2, Figure 3) the wash water pH level was maintained above pH 10.

In conclusion, a pH above 10 has a positive effect on most wastewater variables.

REFERENCES

Anellis, A., J. Lubas and M.M. Rayman. 1954. Heat resistance in liquid eggs of some strains of the genus *Salmonella*. Food Res. 19:377-395.

Bartlett, F.M., J.M. Laird, C.L. Addison and R.C. McKellar. 1993. The analysis of egg wash water for the rapid assessment of microbiological quality. Poultry Sci. 72:1584-1591.

Brant, A.W. and P.B. Starr. 1962. Some physical factors related to egg spoilage. Poultry Sci. 41:1468-1473.

Carawan, R.E., J.V. Chambers, R.R. Zall and R.H. Wilkowske. 1979. Egg Processing Water and Wastewater Management. Extension Special Report AM-18H, North Carolina Agricultural Extension Service, Raleigh, NC.

Cotterill, O.J. 1968. Equivalent pasteurization temperatures to kill *Salmonella* in liquid egg white at various pH levels. Poultry Sci. 47:354-365.

Food Production and Inspection Branch. 1983. Manual of Operation for Effective and Efficient Washing of Eggs. Food Production and Inspection Branch, Agriculture Canada. Ottawa, ON, Canada.

Hamm, D., G.K. Searcy and A.J. Mercuri. 1974. A study of the waste wash water from egg washing machines. Poultry Sci. 53:191-197.

Holley, R.A. and M. Proulx. 1986. Use of egg washwater pH to prevent survival of *Salmonella* at moderate temperatures. Poultry Sci. 65:922-928.

Kinner, J.A. and W.A. Moats. 1981. Effect of temperature, pH and detergent on survival of bacteria associated with shell eggs. Poultry Sci. 60:761-767.

Laird, J.M., F.M. Bartlett and R.C. McKellar. 1991. Survival of *Listeria monocytogenes* in egg washwater. International J. of Food Microbiology 12:115-122.

MANURE REDUCTION, HOUSE FLY CONTROL AND PROTEIN FEEDSTUFF PRODUCTION WITH THE BLACK SOLDIER FLY

D. Craig Sheppard and G. Larry Newton
Departments of Entomology and
Animal and Dairy Science
UGA Coastal Plain Experiment Station
Tifton, GA 31793

Sidney A. Thompson
Department of Biological and Agricultural Engineering
University of Georgia
Athens, GA 30602

A manure management system for laying hens using the black soldier fly, *Hermetia illucens* (L.) converted manure to a 42% protein, 35% fat feedstuff, reduced manure accumulation by at least 50% and eliminated house fly breeding. No extra facility or added energy was required. Mature larvae self-harvested producing a feedstuff as they attempted to pupate. Optimal manure to feedstuff dry matter conversion efficiency was 8%. Estimated economic benefits were 27¢ per hen. This insect occurs worldwide in tropical and warm-temperate regions and can digest many biological wastes.

Manure is the principal food of many insects, especially larval flies. This insect utilization aids in the natural recycling of manure, and the insects produced are food for many larger animals. Several researchers have proposed using manure as a larval fly medium, thus producing high quality insect based feedstuff, while reducing manure residue. Feeding studies and chemical analyses with various fly based feedstuffs have shown them to be generally equal to soybean meal in feed value to poultry.

Previously proposed production and collection systems for house flies, face flies or blow flies involved moving manure from animal production facilities to insectaries. There, specialized equipment was utilized to produce and harvest the insects. This greatly increases the cost of production.

The system we report here utilizes wild populations of the black soldier fly, *Hermetia illucens* (L.), directly under caged layers. No separate facility or special equipment is needed for production or harvest. This is possible due to certain habits of this large wasp-like fly, i.e. it is not a significant pest (especially as managed in our system), and the migrations of the last immature stage facilitate a simple self-collection of the mature larvae.

Soldier fly larvae have been fed experimentally to several animals, with larvae used to replace soybean or fish meal in a formulated diet. These feeding tests have utilized cockerels, pigs and catfish and tilapia. The general conclusion of each of these studies was that soldier fly larval meal was a suitable replacement for conventional protein and fat sources. Soldier flies show an amazingly wide range of larval habitats and have been collected from manures, rotting fruits and vegetables, catsup and dead animals. Little is known about the adult biology of this insect. Adults seen at animal housing, or other larval habitats, are newly emerged adults and older females returning to oviposit. Adults apparently live in a wild environment. Unlike house flies, they very rarely enter dwellings.

The last immature stage is the prepupa, a nonfeeding migratory stage. A prepupal soldier fly has emptied its gut of waste and developed a large fat body to provide energy for its migration and pupation to an adult. An empty gut and maximal stored energy make this the desired stage to collect for feedstuff. This nonfeeding prepupae has its mouth parts modified into a hook, enabling it to travel some distance from the larval habitat and dig into the soil to pupate.

Soldier flies compete with house flies for larval habitat. Female house flies do not lay eggs where soldier fly larvae are moderately abundant. Workers in California, Florida, North Carolina and Georgia reported house fly control where soldier fly larvae were abundant.

MATERIALS AND METHODS

A 460 hen, 12m long caged layer house was modified with 30 cm deep, concrete manure basins under the cages. The basin wall towards the outside of the curtain sided house sloped up at ca. 40°. A 10 cm diam. plastic pipe was fixed along the top of this slope. A 1½ cm gap was cut along the length of this pipe and positioned at the top of the 40° sloped wall. This slit allowed migrating prepupae to enter the pipe. Down-spouts at each end directed prepupae into holding containers.

A small tractor was fitted with special scrapers configured to the shape of the basins. This pushed the residual manure to the end of the house.

About 15L of larvae were inoculated into the basins in August 1990 to initiate a dense population. Prepupal collections in 1991 were collected and weighed. Ten percent of these were released to establish the next generation.

RESULTS AND DISCUSSION

The introduced soldier fly larvae established a resident population, and about 40 kg of prepupae were collected in late 1990. Returning females established a larval population in 1991 and no new introductions were needed. Ovipositing females began appearing regularly by mid April. By late May a solid layer of soldier fly larvae, several deep, occupied the basins. Prepupal self-collections were irregular until late May. Prepupal crawl-off on peak days during June blocked the 10 cm diam. collection pipe. A pipe with a 15cm diam. performed well. Numbers of prepupae self-collected are illustrated in Figure 1 with weekly average temperatures and monthly average weights.

The pattern of prepupal crawl-off indicates that there are three generations each year. Peaks are from late May to late July, late July to early September and early September to mid-November. These peaks lasted 9 weeks, 6 weeks and 9 weeks, respectively. These generation times agree with the reported larval and pupal minimal residence times.

The dense soldier fly larval population prevented house flies from reproducing from May through January. Very few adult house flies were usually present, but were probably migrats. Routine inspections did not reveal any house fly larvae during the summer and fall when soldier flies were abundant. Nearly all adult soldier flies seen at the facility were ovipositing females, which did not cause problems.

Manure accumulations were easily scraped from the basins with the small tractor. The manure was scraped into a sump, water was added, and the slurry was drawn into a vacuum tank manure spreader, and applied onto pastures. The soldier fly-digested manure did not handle differently than other manures and no problems were encountered.

Soldier fly larvae converted manure to larval biomass at up to 8% efficiency. Larval production and self-collection occurred with no external insectary or energy input. House fly production was *eliminated* from May to January. Manure residue was reduced 50% or more and was easily handled with conventional equipment.

The economics of this system are attractive. Construction costs should be less than for a flush system and resource recovery is greater. Larvadex® costs an egg producer 10¢ per hen if used for 6 months. Thus a conservative value to place on house fly control with this soldier fly system is 10¢ per hen per year. Manure removal and surface application costs 28¢ per hen, per year in high-rise houses. Assuming 50% reduction in manure build-up for half the year gives a net 25% reduction. Actual reduction may be much more in future systems. At any rate, the conservative 25% estimate produces an economic benefit of 0.25 x 28¢ = 7¢ per hen per year. Value of the dried larval feedstuff has been estimated at $340-400 per ton. At 44% dry matter, the fresh larvae are worth about $160 per ton or 8¢ per pound. So, the 1.32 lb of larvae produced per hen per year is worth 10.6¢. Adding the easily measured economic benefits of this system yields a total value of 27.6¢ per hen per year. This could net a hypothetical 100,000 hen egg producer an extra $27,600.

Commercial use of this system seems feasible and economically attractive. Many caged layer farms in Georgia and Florida are heavily populated with soldier fly larvae each year. Increasing research scale from 11 hens per basin to 230 increased efficiency of manure to feedstuff conversion from 1.7 to 8%; increased scale favors this insect. Manure can be converted to $300-400 per ton, high quality feedstuff, while reducing manure residue 50%+ and eliminating house flies.

PROCESSING

WORKSHOP

DEVELOPING A WATER CONSERVATION AND WASTE MINIMIZATION PLAN

Conducted by:

Roy Carawan	North Carolina State University
Lewis Carr	University of Maryland
Thomas Carter	North Carolina State University
Eldridge Collins	Virginia Tech
William Merka	The University of Georgia
Chuck Ross	Georgia Institute of Technology
Edd Valentine	Georgia Institute of Technology
Egerton Whittle	The University of Georgia

During the previous two days, speakers have presented data that they have collected to define water use and wastewater loading patterns. In their presentations, the speakers have given only brief explanations of their data collection methods. These explanations may have been too brief to be used in the development of an in plant study. The purpose of this workshop is to give a detailed method to develop a water conservation and a waste minimization plan.

Is the development and implementation of a minimization plan worth the effort?

This will be a management decision based on individual plant situations.

A starting point will be an assumption of a broiler processing plant.

250,000 birds per day
5.5 gallons per bird
$3.00 per 1,000 gallons for water and wastewater treatment
0.08 pounds of BOD_5 per bird at 3 cents per pound for BOD_5 treatment

After water conservation and waste minimization plan implemented.

250,000 birds per day
3.5 gallons per bird
$3.00 per 1,000 gallons for water and wastewater treatment
0.04 pounds of BOD_5 per bird at 3 cents per pound for BOD_5 treatment

Cost Savings:

500,000 gallons per day at $3.00 per 1,000 gallons = $1,500 per day
10,000 pounds of BOD_5 at 3 cents per pound = $300

Total daily savings = $1,800

Annual Savings (260 days per year) = $468,000

Based on this plant assumption, there is an opportunity to reduce costs by almost a half million dollars per year. As water costs increase, the annual savings will probably approach $1 million per year by the turn of the century.

CALCULATIONS OF FLOW VOLUMES

Water Meters

Water meters commonly used in poultry processing plants measure water in 1000's of gallons, 100's of cubic feet and 100's of gallons. Water and wastewater costs are calculated either **1,000's of gallons** or **100's of cubic feet**. One hundred cubic feet of water contains 748 gallons. For simplified calculation, 750 gallons per 100 cubic feet can be used.

Reading water meters accurately seems to be a simple task, however, many times unless people are trained, the data collected is not accurate.

There seems to be four common errors.

1. The fixed zeros are not consistently recorded.

2. In reading five digits on the meter face, one digit will not be recorded.

3. A pair of digits are reversed.

4. The time when meters are read is not accurately recorded.

To accurately read water meters, the following method has been successful.

1. Denote the fixed zeros by drawing a line over the fixed zero's. Example: 089437000.

2. Have the meter reader count the number of recorded digits to insure that a digit was not omitted in recording.

3. Have the meter reader compare the number recorded with the display on the meter face to insure that a pair of digits were not reversed in recording.

4. Record the time that the meter was read to the nearest minute. If reading water meters hourly to profile a flow, a five minute variation in the time of reading will cause an 8 percent error in the flow volume calculation.

Exercise 1:
A water meter measuring in 1,000 of gallons was read at hourly intervals to determine hourly water costs. Water and wastewater was billed by the municipality at $2.25 per 100 cubic feet. What was the hourly cost?

Time	Meter Reading	100's ft^3	Cost
9:00 am	059341000		
10:00 am	059401000		
11:00 am	059463000		
9-10 am	059401000		
	059341000		
	60,000 gallons		
10-11 am	059463000		
	059401000		
	62,000 gallons		

Exercise 2:
Water meters that read in 100's of gallons are placed on two inside/outside bird washers. The meters were read at the beginning of processing (7:00am) and again at the end of the second processing shift (11:00pm). If water and wastewater cost $2.25 per 100 cubic feet, how much did it cost to operate each inside/outside bird washer each day?

	Meter Reading		Cost/day	
Time	M1	M2	M1	M2
7:00 am	472300	646200		
11:00 pm	481900	665400		

FLUMES

Flumes are flow measuring structures made to a geometrical shape so that a flow height at a certain point can be converted to a flow volume. The most common flume installed in the waste stream of poultry processing plants is the Parshall flume. Although many plants have Parshall flumes installed in the waste stream, few plants use them to calculate flow patterns. The flume can be a valuable device to calculate flow and waste loading patterns.

To accurately measure, the Parshall flume should be properly installed.

1. The flume should be installed so that the bottom of the throat section is level in both the long axis and cross axis.

2. Free flow conditions should exist in the Parshall flume. To determine if free flow conditions exist, the flow height should be measured at point Ha and Hb. If the ratio of flow height between Ha and Hb is greater than 0.60 then free flow conditions do not exist and the equations for free flow conditions will not give accurate flow measurements unless flow heights at both Ha and Hb are measured simultaneously. The calculations for submerged flow conditions are more complicated than free flow conditions. It is probably easier to modify the flume to give free flow conditions than to do the more complicated calculations required for submerged flow conditions. When free flow conditions exist, the flow height at Ha is measured and converted into flow volumes.

The most common Parshall flume used by poultry processors seems to be the 6 inch flume although some 9 and 12 inch flumes are used.

To calculate the flow volume through a Parshall flume, the flow height at Ha is measured in inches and the flow height is converted to decimal feet.

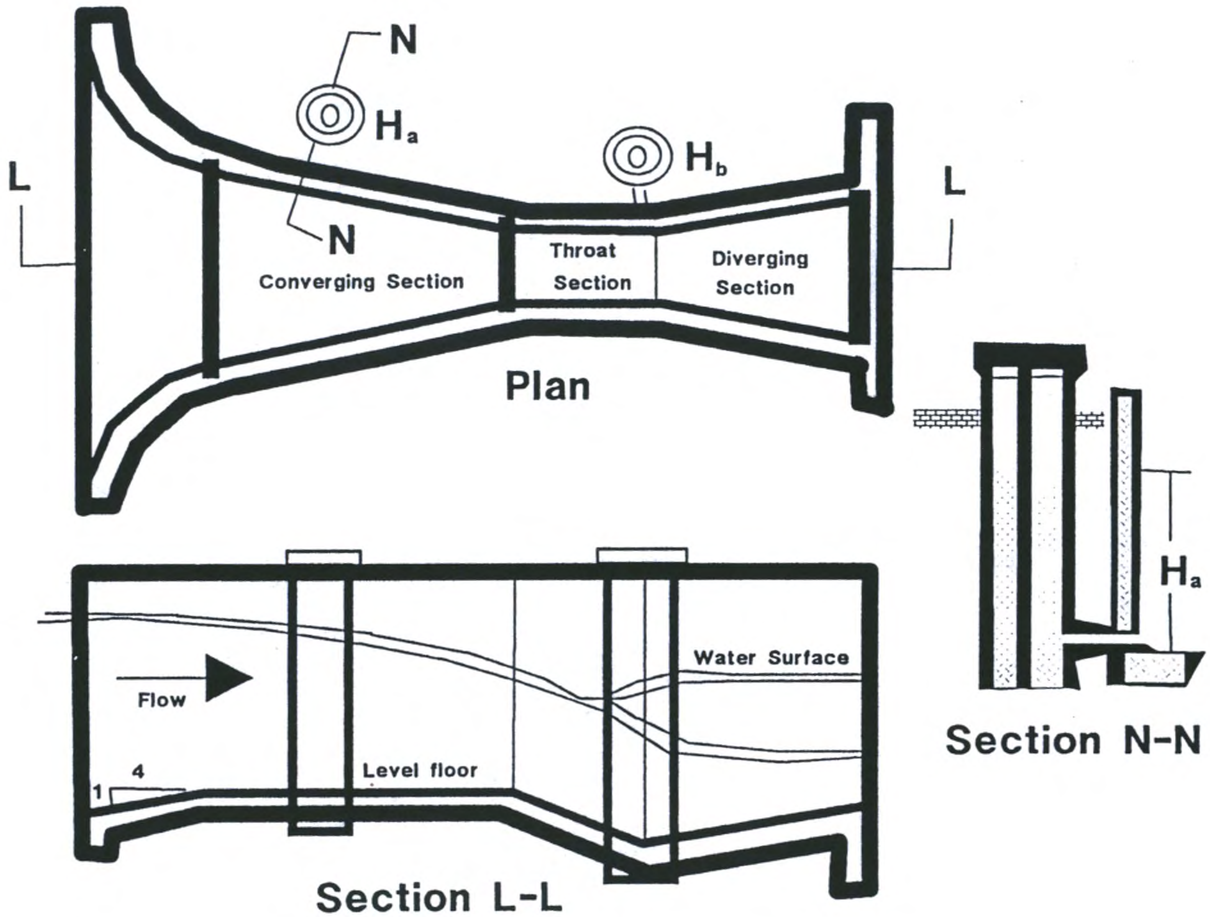
Example:

A flow height of 6 inches is measured at Ha in a 6 inch Parshall flume.

$$\frac{6 \text{ inches}}{12 \text{ inches}} = 0.50 \text{ feet} = H$$

This value is plugged into the equation for a 6" Parshall flume for "H".

$$CFS = 2.06\ H^{1.58} = 2.06\ (0.5^{1.58}) = 0.69\ CFS = \text{cubic feet/sec}$$



The Parshall Measuring Flume

Legend

H = Flow height   L = Length

N = Depth of depression in throat below crest

The solution to the equation gives flow volumes in cubic feet per second.

Tables can also be used.

Exercise 3:
The flow height through a 6" Parshall flume was measured at:

A. 6"

B. 9"

C. 12"

What was the flow volume in gallons per second at each of these flow heights?

WEIRS

A weir is a geometrical shape cut into a flat surface. Based on the geometrical shape, like the Parshall flume, a measured flow height can be converted to a flow volume. There are several types of weirs, however, for the purposes of this exercise the "V" notch weir will be used because it is the most common type used in poultry processing.

A. To properly install a "V" notch weir there must be sufficient change in elevation of the water so that a free air space can form under the discharge of the weir.

B. The weir should be installed perpendicular to the flow.

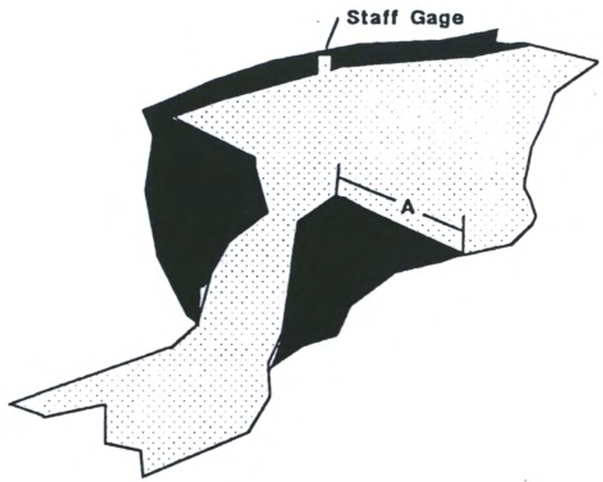
C. The edge of the weir should be sharp and debris must be kept from the crest for accurate measurement. A "V" notch weir will not accurately measure flows that have large solids such as feathers and viscera as they will rapidly plug the "V" notch.

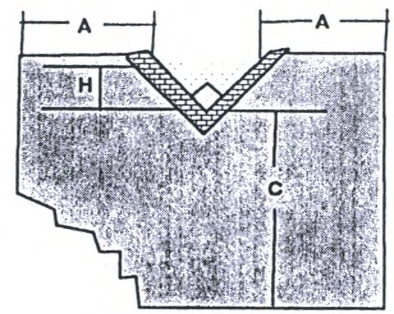
D. A clean out plug should be installed in the weir plate at a point below the "V" notch. Solids tend to settle behind the plate. When this space fills with solids, measurement accuracy is reduced.

E. Flow height through the weir is measured at a point behind the "drawdown" point of the weir. The flow height should be measured no closer to the weir plate than 3-4 times the maximum flow height through the weir.

To calculate the flow volume through a 90 degree "V" notch weir, measure the flow height in inches and convert it to decimal feet as in the Parshall flume.
Example: Flow height = 6"
6/12 = 0.5 feet of flow height

90° V Notch Weir





upstream side

Legend

A = Greater than twice H

C = At least twice H

H = Maximum head

To determine the flow volume through a 90 degree "V" notch weir use the equation 2.5 $H^{2.5}$ where H is the flow height in decimal feet.

2.5 ($0.5^{2.5}$) = Flow volume in cubic feet per second (CFS) = 0.44

Exercises 4:
What is the flow volume in gallons per second when the flow height through a 90 degree "V" notch weir is?

3"

6"

9"

12"

PIPES

Flow volumes through pipes can be determined by measuring the flow height through the pipe, the flow velocity and the slope of the pipe, however, the method is complicated and would require more time than is available in this workshop.

FLOOR DRAINS

An estimation of flow through a rectangular floor drain can be calculated by measuring the width of the floor drain, the flow depth and the flow velocity.

Example:
The depth of water flowing through a 12 inch wide rectangular floor drain is measured at 6 inches. A 10 foot section of the floor drain is laid off. Dye is added into the water and the time required for the dye to move 10 feet is measured at 10 seconds. What is flow volume?

$$\frac{10 \text{ feet}}{10 \text{ seconds}} = 1.0 \text{ ft per second}$$

Flow height $\frac{6 \text{ inches}}{12 \text{ inches/ft}} = 0.5 \text{ ft}$

Flow width $\frac{12 \text{ inches}}{12 \text{ inches}} = 1.0 \text{ ft}$

Width x Height x Velocity = Cubic feet per second
1.0 x 0.5 x 1.0 = 0.5 cubic feet per second

This procedure should be repeated 4 to 5 times and an average flow calculated.

Exercise 5:

	Drain Width	Flow Height	Flow Velocity	Flow Volume gal/sec
A	12 inches	6 inches	1.0 ft/sec	
B	12 inches	4 inches	0.75 ft/sec	
C	12 inches	12 inches	1.5 ft/sec	
D	12 inches	8 inches	1.25 ft/sec	
			Average Flow	

MEASURING VOLUMES BY TIMING

Flow volumes from hoses, pieces of equipment, goosenecks, etc. can be determined by measuring the time required to collect a volume or weight of water.

A. Time required to collect a volume. A container that is calibrated in quarts is placed under the flow and the time required to collect a volume is measured.

Exercise 6:
A plant processes eight hours per day 260 days per year. What is the annual cost of operating these four goosenecks? Water cost $3.00 per 1000 gallons.

	Volume Collected	Time	Gallons per Minute	Annual Cost
1.	3 quarts	30 seconds		
2.	2 quarts	45 seconds		
3.	5 quarts	20 seconds		
4.	2 quarts	30 seconds		

(a) Divide seconds by 60 seconds per minute to determine the fraction of a minute required to collect the measured volume.

$$\frac{30 \text{ sec}}{60 \text{ sec/min}} = 0.5 \text{ minutes}$$

(b) Divide volume by fractional minute.

$$\frac{3.0 \text{ quarts}}{0.5 \text{ minute}} = 6.0 \text{ quarts per minute} = 1.5 \text{ gal/min}$$

(c) Calculate annual cost.

1.5 gal/min x 60 min/hr x 8 hrs/day x 260 processing days/yr = Annual gallons

$$\frac{\text{Annual gallons}}{1{,}000 \text{ gallons}} \times \$3.00/1{,}000 \text{ gallons} = \text{Annual Cost}$$

B. Weight of water collected in a measured time.

Flow volumes can also be calculated by measuring the time required to collect a weight of water and then converting the weight of water to a volume of water. WATER WEIGHS 8.34 POUNDS PER GALLON.

Exercise 7:
The container weighed 3 pounds.

	Weight Collected	Time	Gal per Minute	Annual Cost
1.	7.5 lbs	20 secs		
2.	6.5 lbs	15 secs		
3.	9.0 lbs	30 secs		
4.	10.0 lbs	40 secs		

(a) Measure weight of water and divide by 8.34 to give volume in gallons.

(b) Divide seconds by 60 to give fractions of minutes.

(c) Divide volume by fraction of minute to give gallons per minute.

(d) Calculate annual cost as in previous problem.

Measuring flow volumes by weight is a more accurate method than measuring by volume, however, the weighing method requires a scale that can be moved around the plant. Carrying buckets of water to a central scale will be very time consuming. When selecting a method, the ease of data collection versus accuracy should be considered.

CALCULATION OF VOLUMES OF ROUND AND SQUARE TANKS

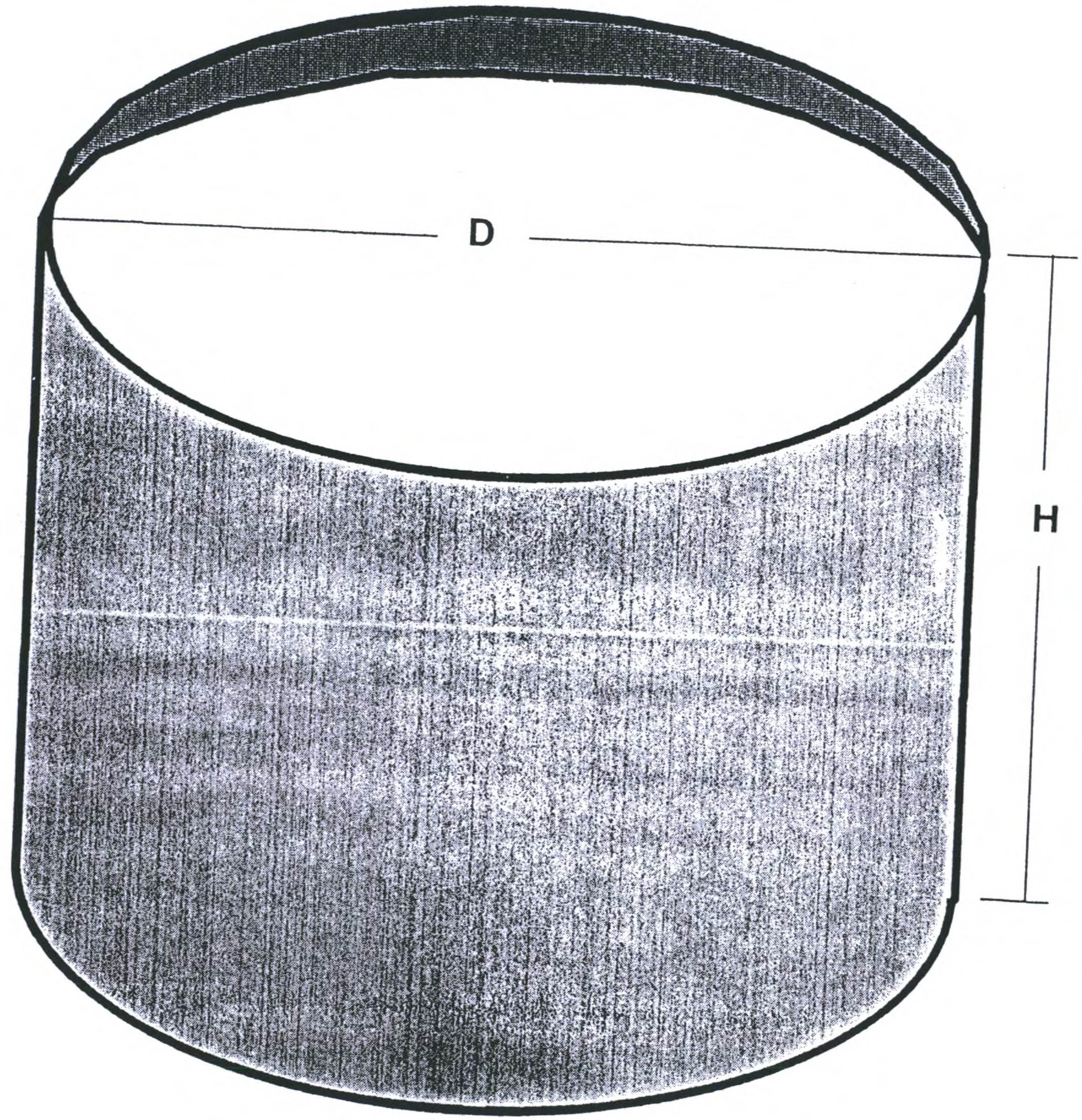
Calculation of tank volumes is important so that detention times for treatment can be determined. Round, square or rectangular tank volumes are determined by calculating the cubic foot volume of the tank. Gallons are calculated by multiplying the cubic foot volume by 7.50 gallons per cubic feet.

Volume of Round Tanks

To determine the volume of a round tank the following equation is used.

Volume in cubic feet = area of round top of the tank x depth of the tank

Round Tank



Legend

D = Diameter

H = Height

R = Radius = D/2

Area of top of the tank = π(radius ^{2}) = πr^2
The radius is the distance from the center of the tank to the outside wall. π(pi) is a constant and equals 3.1416

Example problem:
A round tank is found to have a radius of 25 feet and a depth of 10 feet. How many gallons of water will it hold?

Cubic feet = $\pi(25^2)$ = $\pi(625)$ = 3.1416 (625) = 1964 square feet
1964 square feet x 10 foot depth = 19,6450 cubic feet
19,640 cubic feet x 7.50 gal/cubic foot = 147,725 gallons

Exercise 8:

Tank depth	Tank radius	Volume ft^3	Volume gallons
5 ft	10 ft		
10	30		
20	25		

Volume of Square Tanks

To determine the volume of square or rectangular tanks the height (H), length (L) and width (W) of the tank is measured in feet. The equation, HxLxW = cubic feet, will calculate the volume.

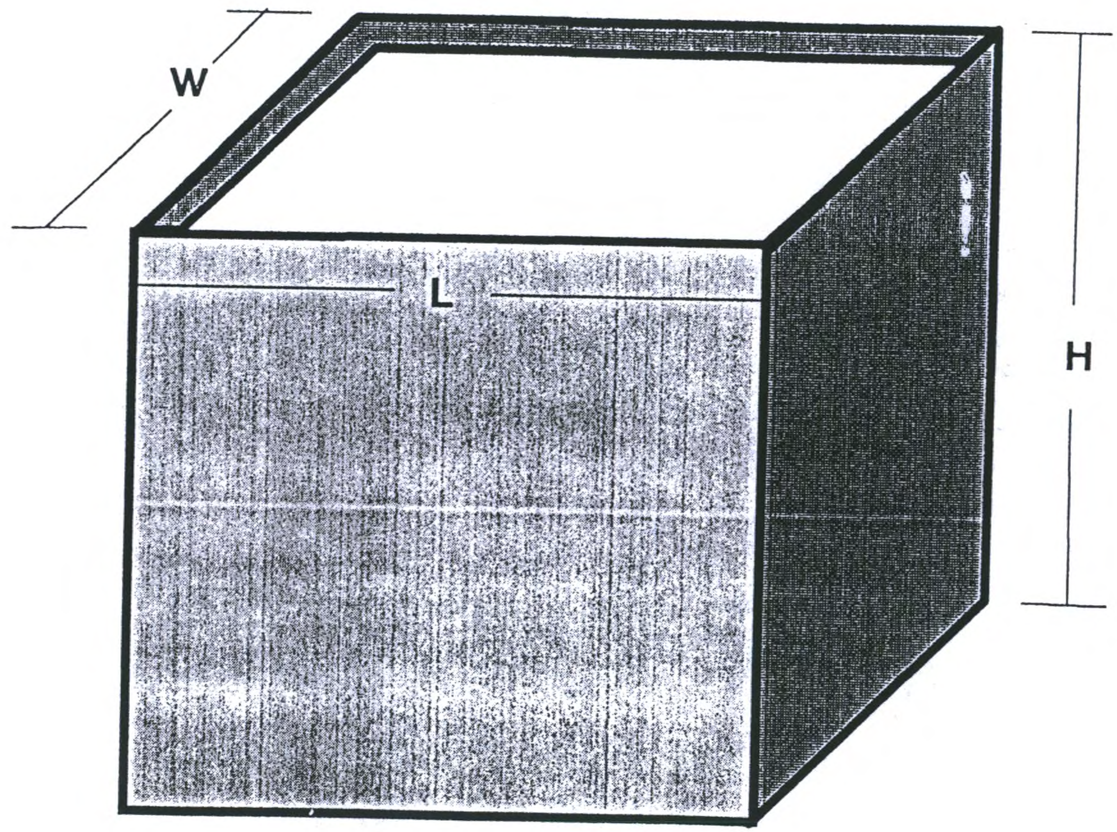
Example:

Length = 40′
Width = 10′
Height = 10′

L x W x H x 7.50 gal/ft^3
40 x 10 x 10 x 7.50 = 30,000 gallons

Exercise 9:
A DAF tank has a length of 30′, a width of 12′ and a depth of 8′. Water flowing into the tank is flowing through a 90° "V" notch weir. The flow height through the "V" notch weir is measured at 9". What is the detention time of the tank at this flow rate?

Square Tank



Legend

H = Height

L = Length

W = Width

BIOCHEMICAL OXYGEN DEMAND

Biochemical Oxygen Demand (BOD) measures the amount of oxygen required for microorganisms to digest organics in the waste stream to a stable form. When organics are discharged into a water course, the naturally occurring aerobic microorganisms digest the organics. In the digestion process, they consume oxygen dissolved in the water. If oxygen consumption is more rapid than it can be replaced from the atmosphere then the dissolved oxygen is depleted and aquatic organisms such as fish die from oxygen starvation. When dissolved oxygen concentrations are depleted below 1-2 mg/L the anaerobic microorganisms begin to digest the organics. Anaerobic digestion is not as complete as aerobic digestion and produces toxic compounds such as ammonia and H_2S. These anaerobic digestion compounds also produce noxious odors.

The BOD test was developed to determine the amount of oxygen required by the aerobic microorganisms to digest the organics. The test is performed by measuring the concentration of dissolved oxygen in a wastewater sample and incubating the sample at 20° C for 5 days in a sealed bottle. The difference in the Day 0 (DO_0) and Day 5 (DO_5) oxygen concentration is the amount of oxygen consumed and is called the BOD_5.

Example:
$DO_0 - DO_5 = BOD_5$ (mg/L)
$8.2 - 3.2 = 5.0$ mg/L of BOD_5

The microorganisms required 5.0 milligrams of oxygen to digest the organic matter in 1 liter of this wastewater.

Oxygen is poorly soluble in water. Only 8.0-8.4 mg of oxygen will dissolve in one liter of water. The organics in processing wastewater require much more than 8 mg/L of oxygen for microbial digestion. If undiluted wastewater is incubated, the microorganisms will rapidly deplete the oxygen and after 5 days of incubation there will be 0 mg/L of dissolved oxygen. The only thing you know is that the BOD_5 is greater than 8.2.

$DO_0 - DO_5 = BOD_5$
$8.2 - 0 = \ >8.2$ mg/L BOD_5

To solve this problem, the wastewater is diluted with water that has no oxygen demand. The dilution or series of dilutions are made so that all of the oxygen will not be depleted during incubation. Poultry processing final plant effluent normally has a BOD_5 of 1500 - 2000 mg/L. An appropriate dilution for this wastewater would be a 1:500 dilution, i.e., 2 mls of the wastewater is added to 998 mls of dilution water. The oxygen depletion over 5 days is measured and the depletion is multiplied by the dilution factor to give the BOD_5.

$DO_0 - DO_5$ x dilution factor = BOD_5
8.2 - 4.2 x 500 = 2,000 mg/L BOD_5

Exercise 10:

	DO_0	DO_5	Dilution Factor	BOD_5
1.	8.2	5.2	250	
2.	8.2	3.4	500	
3.	8.2	2.5	1,000	
4.	8.2	6.0	100	
5.	8.2	3.3	250	

CHEMICAL OXYGEN DEMAND

Chemical Oxygen Demand (COD) is a rapid method (2 hrs) of determining the concentration of organics in a waste stream. The test is based on using an oxidizing agent, potassium dichromate, sulfuric acid and catalysts (mercuric chloride and silver chloride) to chemically oxidize the organic matter. As the organic matter is oxidized the orange dichromate ion is reduced to the green chromium ion. The amount of organic matter oxidized is in proportion to the reduction of dichromate to chromium ion.

The color change is measured in a colorimeter or a spectrophotometer and expressed on a scale as mg/L COD.

COD is a rapid method of estimating the BOD_5 of a wastewater sample. The ratio of BOD_5 to COD in final plant effluent is about 2:1. To estimate BOD_5 divide COD by 2. Waste streams high in fat tend to have a higher BOD_5 to COD ratio, whereas, those low in fat have a tendency to have a lower BOD_5, COD ratio. Both tests should be run on a waste stream to establish the ratio.

TOTAL SUSPENDED SOLIDS (TSS)

Total Suspended Solids (TSS) is a procedure to measure the concentration of particulate matter in a wastewater sample. The TSS concentration is determined by filtering a measured volume of wastewater through a preweighed glass fiber filter. The filter is then dried at 103°C for 1-2 hours and reweighed. The weight picked up by the filter is the amount of particulate matter removed from the wastewater.

Example:
One hundred mls of wastewater was passed through a glass fiber filter that weighed 0.2500 grams. The filter was dried and reweighed at 0.3000 grams. What was the TSS (mg/L) of the wastewater sample?

$$\frac{\text{Filter + Sample Wt. - Filter Wt.}}{\text{mls of wastewater sample}} \times 1{,}000{,}000 = \text{mg/L TSS}$$

$$\frac{0.3000 - 0.2500}{100} \times 1{,}000{,}000 = 500 \text{ mg/L TSS}$$

Exercise 11:

Filter + Sample	Filter Wt.(gms)	Volume(mls)	TSS (mg/L)
1. 0.2727	0.2500	100	
2. 0.2844	0.2494	50	
3. 0.3133	0.2500	100	
4. 0.2903	0.2487	75	

TOTAL VOLATILE SOLIDS

Total Volatile Solids (TVS) measures the concentration of organic matter in a wastewater sample. The results can be obtained in 24 hours. TVS has an advantage over BOD_5 and COD because larger samples of wastewater can be used. BOD_5 is limited to 2-4 mls of wastewater and COD is limited to 2 mls. Many times it is difficult to accurately sample a wastewater sample using only 2 mls of sample. The sample volume of TVS is limited only to the practical size of a crucible.

TVS concentrations are determined by delivering a measured volume of wastewater into a tared clay crucible. The crucible and sample are dried to dryness at 103° C, usually 12-24 hours. The crucible is then cooled and weighed. It is then ashed in a muffle furnace at 550° C until the organic matter is burned, usually about 30 minutes. The crucible is then cooled and reweighed. The weight lost in the ashing process is the amount of organic matter in the wastewater sample.

Example Problem:

$$\frac{\text{Dried wt(gms) - Ashed wt(gms)}}{\text{sample volume}} \times 1{,}000{,}000 = \text{TVS mg/L}$$

Dried crucible + sample	62.1922
Ashed crucible + sample	62.1244
Sample Volume	100 mls

$$\frac{62.1922 - 62.1244}{100} \times 1{,}000{,}000 = 678 \text{ mg/L TVS}$$

Exercise 12:

	Volume(mls)	Dry wt(gms)	Ashed wt (gms)	TVS mg/L
1.	100	59.9203	59.7727	
2.	100	55.5544	55.4000	
3.	100	61.7727	61.6011	

DEVELOPING A WASTEWATER PROFILE

To develop a wastewater profile, two types of data are necessary.

1. The volume of wastewater discharged.
2. The concentration of contaminants in that wastewater.

Such a profile can determine such things as the amount of organics being discharged into a waste stream, the amount of sludge that will be produced by a DAF, or the amount of biological treatment required to treat a wastewater.

The following equation will determine the pounds of a contaminant in a volume of wastewater:

Gallons of wastewater x 8.34 (wt of 1 gallon of water in pounds) x Concentration of contaminants = Pounds
1,000,000

Example Problem:

The height of wastewater flowing through a 90 degree "V" notch weir was measured at 10 inches during a 1 hour period. Wastewater was sampled during the hour and analyzed for BOD. The sample was diluted 1:500. The DO_0 was 8.2 mg/L and the DO_5 was 5.2 mg/L. How many pounds of BOD_5 flowed through the "V" notch weir during this hour?

Flow volume equation for "V" notch weir:

$CFS = 2.5\ (H^{2.5})$ CFS=Cubic feet per second
$CFS = 2.5\ (10/12^{2.5})$
$CFS = 2.5\ (0.634)$
$CFS = 1.59$

CFS x 7.50 = gal/sec
1.59 x 7.50 = 11.93 gal/sec

gal/sec x 60 = gallon/min
11.93 x 60 = 716 gal/min

gal/min x 60 = gal/hr
716 x 60 = 42,960 gal/hr

$DO_0 - DO_5 \times \text{dilution factor} = BOD_5$ mg/L
$8.2 - 5.2 \times 500 = 1{,}500$ mg/L BOD_5

$$\frac{42{,}960}{1{,}000{,}000} \times 8.34 \times 1{,}500 = 537 \text{ pounds BOD/hour}$$

Exercise 13:
Wastewater flowing through a 6" Parshall flume was measured at a flow height of 13 inches for a 1 hour period. Wastewater was sampled during this time and analyzed for BOD_5, COD, TSS and TVS. The following lab data was obtained. How many pounds of each contaminant flowed through the Parshall flume during this hour?

BOD			mg/L	Pounds
DO_0	DO_5	Dilution		
8.2	4.3	1:300		
COD				
2,400				
TSS				
Filter Wt.	Filter + Sample Wt.	Volume		
0.2525	0.3115	100 mls		
TVS				
Dry weight(gms)	Ashed weight(gms)	Volume		
67.4107	67.2537	100 mls		

By developing this type of data set over a 24 hour period, wastewater costs can be determined by measuring when and why excessive water is used and excessive contaminants are added into the waste stream. The data can be used to help answer the following types of questions.

1. What is our pounds per bird BOD_5 discharge? Pound per bird BOD_5 discharge has been shown to vary between 0.03 and 0.25. Could pretreatment cost, DAF sludge volume, aeration capacity etc. be reduced if less water was used and less contaminants added to the waste stream?

2. Can we increase plant capacity without expanding the waste treatment facility if we are more efficient in water use and contaminant exclusion from the stream?

3. In cook plant, can we determine excessive edible product being wasted by analyzing the waste stream?

EXERCISE SOLUTIONS

Exercise 1:

A water meter measuring in 1,000 of gallons was read at hourly intervals to determine hourly water costs. Water and wastewater was billed by the municipality at $2.25 per 100 cubic feet. What was the hourly cost?

Time	Meter Reading	100's ft^3	$Cost
9:00 am	059341000		
10:00 am	059401000	80.0	180
11:00 am	059463000	82.7	186

9-10 am	059401000
	059341000
	60,000 gallons
10-11 am	059463000
	059401000
	62,000 gallons

Exercise 2:
Water meters that read in 100's of gallons are placed on two inside/outside bird washers. The meters were read at the beginning of processing (7:00am) and again at the end of the second processing shift (11:00pm). If water and wastewater cost $2.25 per 100 cubic feet how much did it cost to operate each inside/outside bird washer?

	Meter Reading		Cost/day	
Time	M1	M2	M1	M2
7:00 am	472300	646200		
11:00 pm	481900	665400	28.80	57.60
gallons	9600	19,200		

Exercise 3:
The flow height through a 6" Parshall flume was measured at:

A. 6" 5.17

B. 9" 9.81

C. 12" 15.45

What was the flow volume in gallons per second at each of these flow heights?

Exercise 4:

What is the flow volume in gallons per second when the flow height through a 90 degree "V" notch weir is:

3" 0.59

6" 3.31

9" 9.13

12" 18.75

Exercise 5:

	Drain Width	Flow Height	Flow Velocity	Flow Volume gal/sec
A	12 inches	6 inches	1.0 ft/sec	3.75
B	12 inches	4 inches	0.75 ft/sec	1.86
C	12 inches	12 inches	1.5 ft/sec	11.25
D	12 inches	8 inches	1.25 ft/sec	6.28
			Average Flow	5.78

Exercise 6:

A plant processes eight hours per day, 260 days per year. What is the annual cost of operating these four goosenecks? Water costs $3.00 per 1000 gallons.

	Volume Collected	Time	Gallons/minute	Annual Cost
1.	3 quarts	30 seconds	1.50	561.60
2.	2 quarts	45 seconds	0.67	250.85
3.	5 quarts	20 seconds	3.75	1404.00
4.	2 quarts	30 seconds	1.00	374.40

Exercise 7:

The container weighed 3 pounds.

	Weight Collected	Time	Gallons/minute	Annual Cost
1.	7.5 lbs	20 seconds	1.62	$606.65
2.	6.5 lbs	15 seconds	1.69	$628.50
3.	9.0 lbs	30 seconds	1.44	$538.70
4.	10.0 lbs	40 seconds	1.25	$471.35

(a) Measure weight of water and divide by 8.34 to give volume in gallons.

(b) Divide seconds by 60 to give fractions of minutes.

(c) Divide volume by fraction of minute to give gallons per minute.

(d) Calculate annual cost as in previous Exercise 6.

Exercise 8:

Tank depth	Tank radius	Volume ft^3	Volume gallons
5 ft	10 ft	1,571	11,780
10	30	28,274	212,058
20	25	39,270	294,525

Exercise 9:

A DAF tank has a length of 30′, a width of 12′ and a depth of 8′. Water flowing into the tank is flowing through a 90° "V" notch weir. The flow height through the "V" notch weir is measured at 9". What is the detention time of the tank?

$30 \times 12 \times 8 = 2880\ ft^3 \times 7.50\ gal/ft^3 = 21,600$ gallons
$2.5\ (H^{2.5}) = 2.5\ (0.75^{2.5}) = 1.22$ cfs $\times\ 7.50\ gal/ft^3 = 9.13$ gal/sec

$$\frac{21,600 \text{ gallons}}{9.13 \text{ gal/sec}} = 2366 \text{ secs} \qquad \frac{2366}{60 \text{ sec/min}} = 39.4 \text{ min}$$

Exercise 10:

	DO_o	DO_5	Dilution Factor	BOD_5
1.	8.2	5.2	250	750
2.	8.2	3.4	500	2400
3.	8.2	2.5	1,000	5700
4.	8.2	6.0	100	220
5.	8.2	3.3	250	1225

Exercise 11:

	Filter + Sample(gms)	Filter Wt.(gms)	Volume(mls)	TSS(mg/L)
1.	0.2727	0.2500	100	227
2.	0.2844	0.2494	50	700
3.	0.3133	0.2500	100	633
4.	0.2903	0.2487	75	555

Exercise 12:

	Volume(mls)	Dry wt(gms)	Ashed wt(gms)	TVS(mg/L)
1.	100	59.9203	59.7727	1476
2.	100	55.5544	55.4000	1544
3.	100	61.7727	61.6011	1716

Exercise 13:

Wastewater flowing through a 6" Parshall flume was measured at a flow height of 13 inches for a 1 hour period. Wastewater was sampled during this time and analyzed for BOD_5, COD, TSS and TVS. The following lab data was obtained. How many pounds of each contaminant flowed through the Parshall flume during this hour?

BOD				mg/L	pounds
DO_o	DO_5	Dilution		1170	616
8.2	4.3	1:300			
COD					
2400				2400	1264
TSS					
Filter Wt.	Filter + Sample Wt.		Volume	590	311
0.2525	0.3115		100 mls		

TVS

Dry weight (gms)	Ashed weight (gms)	Volume	1570	827
67.4107	67.2537	100 mls		

6" Parshall flume equation 2.06 ($H^{1.58}$) = CFS
CFS = 2.06 ($1.08^{1.58}$) = 2.06(1.135) = 2.338 CFS
2.338 x 7.50 gal/ft^3 = 17.53 gal/sec x 3600 sec/hr
= 63,130 gal/hr

Pounds

BOD

$$\frac{63{,}130}{1{,}000{,}000} \times 8.34 \times 1170 = 616$$

COD	x 2400 =	1264
TSS	x 570 =	300
TVS	x 1570 =	827

ISBN 0-96276