PROCEEDINGS

1996 National Poultry Waste Management Symposium

Recycling

Manure

Dead Birds

Water

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

Proceedings

1996 NATIONAL POULTRY WASTE MANAGEMENT SYMPOSIUM

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1996 NATIONAL POULTRY WASTE MANAGEMENT SYMPOSIUM

DATES:

October 21 - 23, 1996

LOCATION:

Marriott-Harrisburg Hotel
Harrisburg, PA

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, four National Symposia have been held in 1988, 1990, 1992, and 1994. Today, environmental concerns for the quality of air we breath, 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 Fifth 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 1996 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 and processing facilities. The Proceedings serves to disseminate this wealth of information to others that were unable to attend.

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

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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. 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.

INTRODUCTION

Richard D. Reynnells
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The 1996 symposium is a continuation of the highly successful series started in 1988 by Extension specialists from throughout the United States. The purpose at that time, and today, was to address emerging issues related to the management of poultry by-products from production and processing facilities.

One rarely hears discussions of whether we need to address environmental issues. Discussions are of how we will develop programs and cooperate with various agencies to improve the management of environmental situations, and to determine the most appropriate and expedient mechanism to minimize any environmental impact of our practices.

Even though we probably should refer to the manure, litter, sludge and other by-products of producing and marketing poultry as a resource, and provide a better term than "waste" to describe these materials, the debate over terminology appears to have subsided. Regardless of semantics, it is important to remember we can not treat these by-products of production or processing as waste and something which must be disposed of as cheaply as possible, and possibly with little regard for the environment. Properly utilized, poultry residues have nutrient value as a soil amendment or a feedstuff, and are a necessary result of utilizing animals as a high quality source of nutrients for humans. Only by focusing our efforts on pollution prevention, while optimizing the overall returns from waste management, it is possible to realize the potential of these recyclable nutrients 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. Good management practices are also an important part of maintaining a good neighbor policy, and help prevent regulatory agencies from having a valid reason to mandate production practices for agriculture.

In keeping with the need to stay ahead of the learning curve for waste management issues, we have refocused this year's program to address current and projected requirements of the poultry system. The program for 1996 will include presentations on company involvement in environmental issues. The presentations on air quality and odor considerations, will include ideas from the swine industry. Spent hen utilization has been expended from an informal special session in 1994 to a full topic area this year. Alternative approaches to waste management are highlighted as a new topic area. the discussion of the importance of Nutrient Management Plan generation and utilization to enhance environmental protection will include case studies, and has been added as a special portion of the Production Section. Other speakers were asked to address current issues related to concerns generated by existing or proposed local and national regulations, to examine the legal and practical solutions to living in a more complex society, and the need for each company to develop and maintain a good neighbor policy.

Previous meetings have included poster presentations, with the 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 this year. Because of the tremendous success of including an international speaker in 1994, we have decided to continue this popular feature. Dr. Peter Van Horne has been invited to share his insight, and the European experience, in a discussion of company involvement in environmental issue. He will also provide his viewpoint on the importance of using valid economic analyses in environmental management.

The primary purpose of this series of meetings is to address 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 participant fill out the evaluation form and 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 1998 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 tentatively selected Maryland as the site for the 1998 meeting.

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:

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Department of Poultry Science
Auburn University, AL 36849-5416

Telephone: 334/844-2640
Fax: 334/844-2641

Please make the check payable to:

National Poultry Waste Management Symposium

We appreciate your interest in pollution prevention and environmental management. We hope the next few days will add to your capacity to understand current problem areas, and your ability to address future environmental challenges.

COMPANY INVOLVEMENT IN EMERGING ENVIRONMENTAL ISSUES: INTERNATIONAL PERSPECTIVE

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Environmental problems can stop farming in certain areas. This can be due to the fact that there is not enough water of acceptable quality available or due to the fact that rules and regulations to alleviate the burden on the environment are too strict to make competitive production possible. To tackle this problem the companies should assist the farmers in coping with those problems.

In this paper, the present situation on environmental issues in Europe will be discussed. For the Netherlands, as a country with a high animal population, the environmental regulations will be discussed in more detail.

EUROPE

The European Union aims to harmonize and hasten environmental policy making within Europe. Targets are formulated in the Fifth Environmental Action Program in order to achieve sustainable development of the agricultural sector (CEC, 1992). Some of the objectives formulated are:

- Maintaining current or reduction of nitrate levels in ground water, and
- reduced incidence of surface waters with a nitrate content exceeding 50 mg per liter.

Also included is a list of actions to be undertaken:

- Strict application of the EU Nitrate Directive,

- setting of regional standards for the emission of ammonia for livestock units, and
- reduction program for phosphate use.

The most far-reaching, and most detailed, of the actions is the EU Nitrate Directive, which was issued in 1991. The overall objective of the Directive is to prevent and reduce nitrate pollution in order to guarantee the quality of water. The maximum standard for nitrate is 50 mg per liter. In response to the EU Directive the member states have to implement a monitoring system, codes of good agricultural practice and a national action program by the end of 1995. Nitrate levels of 50 mg or more may be expected in the Netherlands, Denmark, Belgium, Germany, the southern part of the UK, the Po valley area in Italy and western France (Brouwer et al., 1993). This is due to either the high surplus of nitrogen from agriculture or due to vulnerability of the soil to leaching, or a combination of these two phenomena. The EU Nitrate Directive points out that application of animal manure must not exceed 170 kg nitrogen per hectare by 1999. Compliance with these standards will naturally be most crucial in regions with intensive animal production.

NETHERLANDS

In the Netherlands, problems of pollution by nutrients (N and P) are mainly caused by overproduction of manure in intensive livestock farming in too small an area which has led to a manure surplus. The Netherlands is now pursuing a target of equilibrium manuring by the year 2000. That is to say that the amount of phosphate and nitrogen applied in the form of animal manure and chemical fertilizer will be broadly equal to the amount of nitrogen and phosphate absorbed by the crops. The government set the conditions and companies can decide themselves how they want to meet those conditions. At the beginning of the 1980s, it became clear that manure oversupply resulted in an unacceptable level of mineral pollution of the soil, surface water and ground water. The government began a phased approach (MANF, 1993):

Phase 1 (1987-1990) Stabilization of the problem.
From 1987 a ceiling per farm was set on phosphate production and rules were drawn to further control enlargement of manure production. All farms with animal production got scaled manure production right.

Phase 2 (1991-1994) Gradual reduction.
By tightening the utilization standards the industry got time to solve the manure surplus problem through manure distribution, manure processing and modifying animal feed.

Phase 3 (1995-2000) Achieve equilibrium.
By further tightening of the standards the goal of an equilibrium manuring situation should be achieved.

Especially in the third phase, a lot of attention is given to mineral accounting. The livestock production sector is now using mineral accounting as a management instrument, but in the near future it will be an official governmental instrument. Keeping mineral accounting records will give farmers a picture of the mineral flows on there farm. The farmer can decide for himself whether to dispose of any mineral surplus by switching to a different feed, selling manure to a holding with a manure deficit, by sending manure to a plant for processing or by a combination of these options.

As long as the mineral accounting system is not available, farmers with grassland and arable land will have to manage 'utilization standards' for animal manure. In 1996, the phosphate utilization standard for grassland is 135 kg and for arable land 90 kg. The maximum amount of manure is combined with a ban on spreading in the wintertime. Besides an impact on phosphate supply, this measure is intended to reduce nitrogen emissions.

In the Netherlands, ammonia emission is part of the mineral problem. The government target is to achieve a 70% reduction in emission level relative to 1980, over the period 2000-2005. At the moment a reduction in ammonia emission is achieved by using special techniques to minimize emission during spreading the manure and sealing manure storage facilities. In the near future, livestock housing will have to be modified in order to reduce ammonia emission. Standards and requirements are introduced on housing systems. One of the examples is rapid drying of manure on manure belts in layers houses.

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COMPANY INVOLVEMENT IN EMERGING ENVIRONMENTAL ISSUES: FEDERAL PERSPECTIVE

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Today, the animal confinement industry is at a pivotal point in production versus environmental confrontation. Yes, the swine industry has taken the brunt of the anguish during the last two years, but do not be complacent. More confrontation may be ahead and the industry needs to continue taking a proactive stance to reduce environmental problems.

In addition, the industry may be in a good position for increased exports of their products. The Asian countries are developing a middle class that wants better food quality, more pre-processed foods and greater variety. If world trade conditions become more open, tariffs reduced and other restrictions limited, the industry could see a new spurt of growth.

Therefore, the industry is looking at potential growth and yet, the agricultural sector is being more closely observed by neighbors, environmental advocates, and government than ever before. A balance between growth and protection of the environment will continue to be critical.

Fortunately, the poultry industry has taken some major proactive steps through education and information programs. But again, do not be complacent.

POULTRY INDUSTRY EVOLUTION

The poultry industry has evolved into a very sophisticated marketing and production enterprise. During this evolution, contract production with farmers has become more centralized. The major companies are easily identified by the general public. This centralization may be more economically efficient but be cautious because it has a potential down-side from an environmental perspective. It allows the environmental advocates a very visible target to challenge.

UPCOMING RESOURCE CONCERNS - NUTRIENT OVERLOAD

One area needing attention by the industry is the carrying capacity of the resources for manure. In the past, the density of confinement systems has not been a major problem, especially in the poultry industry who uses the manure as a valuable nutrient resource. Many locations have developed a market for the dry litter from broiler and layer operations. Some of the liquid manure systems may not have such a market. But, generally, enough land is available to apply the liquid and utilize the nutrients from lagoons or holding ponds. However, nutrient overload is being experienced in some locations.

Often, NRCS, other agencies, consultants and farmers have used nitrogen as the limiting nutrient in determining how much manure could be applied to land. A nitrogen balance was calculated for different vegetation and to determine the amount of land to utilize the manure.

Even though the nitrogen balance could be determined, some operators still apply commercial fertilizer at the recommended rates for crops and then spread the poultry litter for an extra nutrient boost or as a means of disposal. This is causing some problems with excess nitrogen and phosphorus leaving the site.

In some locations, some wells are getting high levels of nitrogen in the drinking water and posing health problems. Other locations, surface waters are becoming over enriched from nitrogen and phosphorus and posing some environmental concerns.

When manure is applied at the rate plants can utilize the nitrogen, excess phosphorus is almost always applied due to the concentration of phosphorus in the manure. In the past, it was accepted practice to assume the soil would bind the phosphorus. If erosion control was adequate, then the phosphorus should stay on site. However, some soils have become saturated with phosphorus and releasing high concentrations in the runoff. More receiving bodies of water are experiencing over enrichment from nutrient rich runoff. And, there is not sufficient land to move the manure spreading to another location.

When land is limited, some options that have been offered are:

Deep plowing and mixing or burying the surface soil layers when the surface layer of soil is saturated with phosphorus. The high phosphorus concentrations in the soil surface occurs when the manure is continuously applied to the surface of hay and pasture land. If the land has been in cropland, deep plowing could still work but the plow would have to go deeper than normal. Be sure to practice good erosion control and get the soil surface covered with vegetation as soon as possible. This may only be a temporary solution.

Composting and shipping the composted manure out of the area. This can be expensive and the market opportunity should be thoroughly evaluated. The companies need to understand the limits for the land resources and help prevent nutrient overload.

COMPANY RESPONSIBILITY

Company decisions have a major influence on the potential pollution from poultry operations and most of these decisions have been positive in the past. Everyone recognizes the economic impact on the entire industry from a few pollution problems. However, companies need to be aware of major pitfalls and try to avoid problems. Some suggestions to avoid the pitfalls are:

Preplanning

Preplanning is needed and try to avoid the sensitive areas. Unfortunately, it appears that these are the areas that fit the economic conditions for development of poultry production. These areas can be used but it requires great caution and some good preplanning.

Some indicators of environmental sensitive areas are:

Sink hole country or cavernous limestone where the manure can easily move into the groundwater. Sandy soils over shallow water tables used for human consumption. Sandy soils over shallow water tables that flow to nearby streams. High clay soils on steep topography where runoff quickly and easily occurs. Watersheds above lakes and impoundments.

Constantly Monitor Farmer Actions

The company field staff need to monitor how well the poultry farmers are utilizing their manure and dead animals. Some companies are already monitoring these activities and it is making a major difference. When a contract farm is not being environmentally sensitive, the company needs to take action to correct the problem.

Seek Better Ideas

Always be open to better ideas but field test on a limited basis before expanding the ideas to everyone. An example of a mistake was importing a building designed for layers from

California to the Southeast. The design had excellent production efficiency and low fixed cost. The California company was promoting this design on all new operations in a Southeast area. The manure was managed as a dry stack.

The housing units operated fine for 1 or 2 years and then the Southeast rainfall and humidity promoted a major fly larvae infestation. Overnight, 2 and 3 foot stacks of manure under the cages started moving. It was like the movie "The Slime" and it was killing everything in its path. Major nuisance and water quality problems occurred, lawsuits became frequent, and major building alterations were necessary. All the systems had to convert to flush and liquid manure management systems

Work With the Local and State Government

Don't surprise the local governments. If you do surprise the local officials and problems occur, don't expect much sympathy. Remember, companies are very visible.

Be a Good Neighbor

Probably, the most important idea that the companies could promote with their contractors is "be a good neighbor." Many changes in attitudes have occurred when the contract farmers met with the neighbors and worked out solutions. Some farmers started out with the good neighbor policy and have avoided problems where problems could have easily occurred. Some actions witnessed are:

Spreading manure in neighbors gardens at no charge.
- Providing a community garden or some specialty crop such as sweet corn.
- Spreading manure at night during the summer months.
- Hosting a yearly barbecue.

Remember, the country-side is not composed of just farmers any more. Many urbanites and retirees are returning to the country for clean air, open spaces, beautiful vistas and a better environment. They tend to frown on nearby manure spreading while they are grilling a steak.

FEDERAL ASSISTANCE

USDA Role

The Federal USDA role is to work with the companies and their farmer contractors to develop environmentally friendly manure management systems and help integrate the manure systems into the farming activities. USDA may not have all the answers but we do have some technical expertise and programs that can help. Technical assistance is available through NRCS, Cooperative Extension Service, and the Land Grant Universities.

USDA does not impose regulations on manure management systems. This is the responsibility of state and local government with EPA oversight. NRCS will develop plans and designs for manure management systems to meet the local and state requirements, but this is a service to the landowner. The landowner is still responsible for meeting the laws.

Information

NRCS is striving to develop Geographic Information System (GIS) data bases on soils, geology, plants and current water conditions. Some states have the systems operational and others are still developing the GIS system. This information is valuable for preplanning and understanding constraints. However, do not wait until the GIS system is operational to discuss your planning needs with NRCS staff and the Cooperative Extension Service. Most of the counties have most of this information in reports or other documents and it will give you good information of the potential problems to consider. It just requires time and thinking to put all the information together.

USDA Programs

NRCS and other USDA agencies have some programs that can help the farmers prevent or solve water quality problems. Some of these programs are:

<u>Environmental Quality Incentive Program (EQUIP)</u>:
The recent farm bill provided a cost share program to assist in installation of manure management systems in priority areas. If an operation is in a priority area and manure management is one of the environmental concerns for that area, then financial and technical assistance will be available. In addition, we are reserving a small amount of the EQUIP funds for isolated high priority problems across the country that may not be in a priority area.

NOTE: At the time this manuscript was written, the rules and regulations were not completed; therefore, it is premature to list program conditions.

<u>Conservation Reserve Program (CRP)</u>:
For the first time, a continuous sign-up of the CRP program is going to be available. We believe this will allow a great potential to solve many problems from sheet flow

runoff into streams or remove nutrients from inter-flow into streams.

NOTE: At the time this manuscript was written, the rules and regulations were not completed; therefore, it is premature to list conditions.

Wetland Reserve Program:
There are several locations across the country where restoration of wetlands would have a tremendous benefit to water quality. Gently sloping land with wetland restoration in the small finger streams and ditches receiving runoff will make a big reduction of nutrients leaving the manure application fields.

NOTE: At the time this manuscript was written, the rules and regulations were not completed; therefore, it is premature to list conditions.

SUMMARY

In general, the poultry industry has set some policies and provided education and information programs that are helping to keep a positive view of the industry. However, do not become complacent. A few pollution problems surfacing in the press will tend to have a "snow ball" effect and could hurt the entire industry.

The industry is becoming more visible and companies are easier targets for complaints. If world trade barriers are lifted, the industry could see major growth. At the same time, confined feeding operations are taking a lot of environmental criticism. Be careful and do good preplanning in plant locations and production expansion and most of the environmental problems can be avoided.

COMPANY INVOLVEMENT IN EMERGING ENVIRONMENTAL ISSUES: INDUSTRY PERSPECTIVE

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Good morning! I appreciate the opportunity to be with you all today to discuss the issues at hand. The Virginia Poultry Federation is a trade association representing both growers and processors on issues of common concern with state and local governments. We recognize that the issue of waste management is a pressing one and one that must be dealt with head-on in a forthright manner.

Virginia has perhaps had an opportunity to address these issues sooner than other parts of the country due to the fact that we are participants in the Chesapeake Bay Program. The Bay Program is a joint effort between the states of Virginia, Maryland, Pennsylvania, the District of Columbia and the U.S. Environmental Protection Agency (EPA) to improve the water quality of the Chesapeake Bay. The center piece of the program is the commitment of all participants to reduce the nutrient loadings to the Bay by 40% from 1985 baseline levels by the year 2000. Whether this goal is achievable or not is debatable. Never the less, it does serve to focus attention on sources of nutrients and creates pressure for reductions.

Obviously, the poultry industry is a source of nutrients, both in the nonpoint source area and in the point source area. In 1995, the Virginia poultry industry began to consider what the industry's response should be. Up until that time, our approach had been more reactive than proactive. Rockingham County, the center of poultry production in Virginia, had adopted a poultry ordinance requiring growers to have nutrient management plans in 1988. The ordinance seemed to be working well and our experience with it gave us the opportunity to evaluate nutrient management in the real world.

We found that nutrient management was primarily a matter of education. The better farm managers were the first to implement nutrient management and others followed suit once they understood the practical aspects of nutrient management planning.

These practical aspects included (1) the economic efficiencies of litter utilization as fertilizer (which often saved the farmer thousands of dollars on his fertilizer bill), (2) the Virginia state income tax credit which allows a credit of up to $3,750 on certain sprayers, manure spreaders and fertilizer spreaders if you have a nutrient management plan, and (3) the development of markets for litter used as cattle feed.

As we saw the benefits of nutrient management on the farm, we also recognized that it had substantial benefit in justifying the industry in the eyes of some environmental critics. There is the classic problem of perception versus reality. What the public thinks is the situation versus what the real situation is. Many people, concerned about the Chesapeake Bay, had the image of farmers dumping manure in the creek as the source of the Bay's problems.

Even the environmental bureaucracy of the Department of Environmental Quality (DEQ) held this belief to some extent. A high official of the DEQ said this past march that it was not wise to require sewage treatment plants to spend large amounts of money to lower their nitrogen discharges, because the real problem was coming from farms and feedlots in the Shenandoah Valley. It just goes to show you that we still have a great deal of education to do.

The poultry industry in Virginia has attempted to meet this challenge in several ways. First, on Earth Day, 1995, we made a collective commitment to implement nutrient management planning on every poultry farm in Virginia. All four integrators in Virginia, WLR, Rocco, Tyson and Perdue, agreed that any new grower that signed up with them would be required to have a nutrient management plan in place before birds were placed on the farm. Further, we would seek to have all existing growers operating with a nutrient management plan by the year 2000 or as soon as the state agencies could get them written. In other words, as the commissioner of Agriculture said, "these poultry producers are willing to put in writing how they will protect the environment."

We took out advertisements in the major newspapers of Virginia announcing our commitment. We also presented our commitment to the Secretary of Natural Resources as part of the Tributary Strategy for the Potomac. (This is the Virginia's plan on how to accomplish the goal of reducing nutrients to the Bay by 40% by the year 2000). This was a historic first in Virginia and I believe in the nation. Never before had four major agribusiness companies come together to voluntarily implement a water quality policy. We did receive a fair amount of recognition for our effort. The newspapers reported our commitment in a very positive light, it was written up in EPA's NPS News-Notes, and in November, we were awarded the first ever "Friend of the Bay" award by Governor Allen. The second thing we initiated to address public perception is to recognize that our industry, like all others, has a few bad apples or bad actors as we call them.

Whenever we opposed additional regulation or new legislative mandates, we always argued that voluntary, educational, technical assistance programs were sufficient. We were challenged on that when it was pointed out that a small, distinct minority of farmers do not attend educational meetings or otherwise utilize these programs. Some of these individuals do not care about their impact on their neighbor or the environment. These bad actors are very few in number. The vast majority of farmers are responsible stewards and want to do the right thing. The challenge then was: How do we crack down on these occasional bad actors, without regulating every other farmer who is not causing a problem?

Thus began the discussions that developed into the Agricultural Stewardship Act of 1996. Without going into great detail, Virginia now has a program that will sort out real farm pollution problems from merely perceived ones, address those problems with a site specific solution, and leave the farmer in control of his farm. Only if there is a real pollution problem and the farmer refuses to address it in any meaningful way, will any enforcement mechanism kick in. Ultimately, such an individual could face fines of up to $5,000 per day. But that is at the end of the process. Up to that point, every effort will be made to provide the farmer assistance in addressing the pollution problem.

The Agricultural Stewardship Act is a complaint driven bad actor law, administered by the Commissioner of Agriculture, contains an appeal process to a board that has working farmers on it, and has as its main focus solving problems, not punishing people. The poultry industry was one of the main leaders on this legislation, but it was also supported by virtually every agricultural organization in Virginia.

The third step we are taking in Virginia is to research potential technologies to reduce nutrient loadings on the point source slide, that is from our poultry processing plants. Again, the Chesapeake Bay Program is causing permitted discharges to come under closer scrutiny from nutrient content. EPA has been pressing Virginia to develop a standard for nitrogen to be used in the re-issuance of discharge permits. Such a development would have huge economic consequences for our industry as our wastewater is relatively nutrient rich when compared to domestic sewage. The state EDQ is promoting the use of Biological Nutrient Removal (BNR) at some sewage treatment plants. BNR is an expensive process, depending on whose numbers you use, it would cost between $5.00 and $20.00 per pound of nitrogen removed from wastewater. We applied to the Virginia Environmental Endowment (VEE) for a grant of $10,000 to fund a feasibility study for the implementation of a new treatment process for our wastewater that would reduce nutrient loadings to the rivers and Bay. The VEE funded our project and the study is nearing completion.

The technology consists basicly of a very deep aerobic lagoon stacked on top of an anaerobic lagoon followed by additional deep aerobic treatment cells. This oxygen rich (8-10 ppm) treatment process eliminates odors and practically eliminates the generation of sludge, two chronic problems. The treated effluent is fairly nutrient rich and is irrigated on farm fields resulting in the elimination of the need for a discharge permit, no worries about nitrogen standards and a substantial reduction in the amount of nutrients going to the Bay. While this sounds very appealing on paper, it remains to be seen if the site specific application will have the economics necessary to entice a processor to implement it.

In summary, I believe the poultry industry in Virginia is making a substantial effort to meet the challenge of handling waste, minimizing environmental threats, and maximizing efficiency, both at the plant and on the farm.

AIR QUALITY ISSUES

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The Clean Air Act was passed in 1995. However, air quality issues have become major topics of discussion in livestock and poultry production only in the past few years. Particulates and ammonia emissions are of particular interest in the production of poultry. Particulate studies have been conducted at Pennsylvania State University, University of Minnesota, University of Georgia and other states in the past 15 years. These studies have quantified particulate size from poultry production facilities. At the University of Georgia, CAT scans have been performed on the respiratory tract of poultry in an attempt to determine damage from inhaled particulates.

Ammonia studies can be traced back to the 1940's. Negative performance parameters such as weight gain can be influenced by atmospheric ammonia above 20 ppm in the presence of disease organisms such as Newcastle. Research at the University of Maryland has shown atmospheric ammonia concentrations greater then 50 ppm, without respiratory disease challenge, to have a negative effect on weight gain. Exposures to greater than 75 ppm for a period of three weeks will cause ulceration of the ocular system. Elevated levels of ammonia occur in the cooler seasons of the year primarily because of fuel conservation concerns, expressed as a reduced ventilation rate. Research has shown low concentrations of atmospheric ammonia due to increased ventilation does not necessarily decrease the release from the manure surfaces in the case of floor systems used in broiler production.

Questions are being asked as to what effect the particulates and ammonia exposure from poultry facilities may have on human health. Some states have **INSTITUTES OF AGRICULTURAL MEDICINE AND OCCUPATIONAL HEALTH** which address agricultural health opportunities. Studies have been conducted on poultry growers and workers, but some results may not be conclusive. Well designed long term studies are needed to determine if there are human health concerns for poultry growers and workers.

Today, we will try to understand some of these issues. "Fugitive Dust and Ammonia Emissions" will be discussed by Dr. Deanne Morse, and Dr. Kelley Donham will discuss "Health Consequences".

UNDERSTANDING FUGITIVE DUST AND AMMONIA EMISSIONS

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Natural resources of soil, water and air are in limited supply. An ever increasing human population and changing human activities continues to impact our world. The consequences of local activities are not limited to a specific location.

Contamination of water resources can impact biological activity along miles of a stream or river, or critically impair lakes or oceans. The contamination of an aquifer can change the beneficial use of groundwater. Mitigation of water contamination usually is costly and time consuming. Point sources of contamination are usually identifiable and somewhat correctable. Nonpoint sources of contamination are much more difficult to identify and quite challenging to develop appropriate alterations to improve an impaired water source. The complexity of nonpoint sources of contamination and the underlying lag time between alterations in management practices and a measured change in water quality make it difficult for regulatory people to mandate specific practices.

Human activities associated with air quality concerns can be separated into mobile and stationary sources. Mobile source either move directly (cars, boats, trucks, trains, etc.) or are carried in wind. Stationary sources originate from a specific location.

LEGISLATIVE HISTORY

The Clean Air Act was passed in 1955 (PL 84-159, 1955). This act specifically established National Ambient Air Quality Standards (NAAQS) for six compounds: carbon monoxide, ozone, particulate matter, sulfur dioxide, nitrogen oxides and hydrocarbons. The particulate matter of current concern is PM_{10} (particulate matter of less than 10μ in aerodynamic diameter). There is a movement to also set standards for $PM_{2.5}$. If in fact the standards are set for $PM_{2.5}$, then the contribution from ammonium nitrate will be a larger percent of the total as the fugitive dust components are larger than 2.5μ. The regional EPA or individual state regulatory authorities are required to monitor air quality conditions. In areas where air quality is not in compliance with standards, regulatory agencies are required to develop and implement a plan to improve air quality to meet NAAQS. A Federal Implementation Plan (FIP) must be developed in the absence of an acceptable state or local implementation plan. The Clean Air Act as amended to date has identified time-lines for plan development and implementation. If a particular agency does not comply with the time-line and work toward improving air quality, the agency can be targeted in legal actions.

Nuisance issues related to flies, dust, odors, and noise are regulated at the state or local level. Generally, these nuisances occur in areas where concentrated groups of livestock reside seasonally or year round and urbanization has increased, or when an unanticipated adverse weather condition occurs (rain event or wind shift). Problems associated with seasonal clean-out of houses or dry manure handling can occur.

IMPACT ON POULTRY OPERATORS

Immediate concerns related to concentrated animals and NAAQS include the contribution of manure decomposition to ammonia emissions (SCAQMD, 1991b) and the impact of manure handling on fugitive dust (SCAQMD, 1991a). The photoreaction of ammonia and nitric acid results in the formation of atmospheric ammonium nitrate, a particulate matter of less than 10μ in aerodynamic diameter (PM_{10}). Fugitive dust is that dust which does not return to ground and contributes to reduced air quality. It is smaller than 10μ and therefore fits into the PM_{10} category.

California's South Coast Air Quality Management District (SCAQMD) is drafting rules for emissions reductions from livestock waste (volatile organic compounds (VOC), PM_{10}, and ammonia) (SCAQMD, 1994). The two primary PM_{10} candidate procedures include reduction of road dust (paved, road base topped, or chemically treated), and reduction in dust emissions from feed preparation activities. Ammonia emissions reduction strategies include dietary manipulation, enhanced biodegradation (application of microbial and/or enzymatic products), chemical oxidizers, composting, or other methods to reduce ammonia emissions (anything that reduces moisture content of manure) (SCAQMD, 1996).

The SCAQMD has already estimated potential air quality benefits (reduced formation of particulate nitrate) and detriments (increased production of ozone precursors) if all dairy cattle were removed from the basin. At this point, there is no mention of ammonia emissions reduction from poultry operations. However, they have included estimated poultry emissions in their inventory process and this is the first step to determine industry contribution and the need for management alterations.

Certainly, some management practices are effective in reducting ammonia emissions. Maintenance of waterers is important to minimize moisture content of manure. It is possible that enclosed operations will need to scrub ammonia from air vented from buildings. Both dietary manipulation and use of commercial products on manure are good possible alternatives to reduce nitrogen emissions from manure. Application of chemical products or limited use of thin bed drying may also occur.

KEEPING A WATCHFUL EYE

Recent actions by U.S. EPA Region IX in California implicated livestock (particularly dairy cattle) manure decomposition as a source of emissions of hydrocarbon precursors to ozone (US EPA, 1994). The implications surfaced after a brief literature review was accomplished and in the absence of local data. The proposed FIP resulted from a citizen law suite and would have required collection of 55% of the manure and processing it through an anaerobic digestion system (either a digester for solids or a covered pond for liquids). The purpose of the FIP was to capture emitted gases, generate electricity, and prevent or reduce emissions of undesirable hydrocarbons into the atmosphere as well as to provide a cost recovery mechanism for the operator. **The FIP very closely resembled housekeeping measures originally proposed to reduce hydrocarbon emissions from dairy operations in Southern California** (SCAQMD, 1991a). Although this technology was initially included as part of the initial SCAQMD management menu and its purpose was to allow cost recovery and VOC control, it managed to resurface as a technology for control of ammonia emissions. After considerable effort, it appears that such technologies will not be included, since they may adversely impact ammonia emissions.

The economic impact of the FIP on dairy producers would have been costly for dairy operators (Morse et al., 1996). Actual emissions research conducted on dairies provided data which allowed U.S. EPA not to finalize the livestock component of the FIP (Schmidt and Winegar, 1995). Yet, the concept of this recent example illustrates how the response of a regulatory agency to a citizen law suite can quickly impact livestock operators.

The South Coast Air Quality Management District is in the process of finalizing the management practices to reduce ammonia, volatile organic compound, and PM_{10} emissions from livestock. They are not particularly concerned about developing management practices that specifically reduce VOC emissions. However, the anaerobic digester or covered lagoon technologies remained on their draft list of management practices through mid-June, 1996. The final draft list of practices should become a part of the public record in July, 1996. This scenario is a good example of how one technology initially suggested for reduction of one compound is maintained on a list, even though the compound of concern has changed. Similarly, poultry operators should be concerned about management practices imposed on dairy operators.

SUMMARY

Regulatory development is a slow process. Attention to many of the steps during the development stages may serve to protect poultry operations. It is important to follow development of regulations and acceptable management practices to ensure that regulations do not mitigate the NAAQS concerns and result in increased nuisance complaints.

Although the current concern related to NAAQS is directly related to California's dairy industry, it may soon be directed toward other livestock industries in California and permeate across the country. The implications of developing NAAQS for $PM_{2.5}$ may be large for poultry and other livestock operators. The percent contribution of ammonium nitrate to $PM_{2.5}$ is greater than the percent contribution to PM_{10}. Such standards will impact sulfur oxide producers in industrialized areas as well as ammonia or nitrogen oxides in other parts of the country.

It is critical to identify which prospective management alternatives will be effective and economical, without harming other natural resources. It is essential to evaluate the consequences of management alternatives. For instance, what is the consequence of using a chemical oxidizer on the utilization of the manure? Will it impact soil quality, soil nutrient uptake, or otherwise alter management options?

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AIR QUALITY RELATIONSHIPS TO OCCUPATIONAL HEALTH IN THE POULTRY INDUSTRY

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Respiratory disease is a major health concern among agricultural workers (Haber 1971; Popendorf et al., 1985). Dairy farmers, swine producers, and grain handlers all have significant experience with respiratory disease (Popendorf et al., 1985). Organic dust exposure in agriculture seems to be the generic exposure which induces the inflammatory or allergenic effects responsible for various illnesses observed (Donham 1986). These illnesses include bronchitis, hyper-responsive airways (occupational asthma), mucus membrane irritation, hypersensitivity pneumonitis, organic dust toxic syndrome (ODTS), and atopic asthma (Dopico 1986).

A few studies in the literature suggest that workers in the poultry industry may experience similar hazards. However, large, controlled, industry-wide studies have not previously been conducted. This project, an in-depth medical and environmental epidemiological study, was conducted to identify occupational respiratory hazards that may exist for poultry workers.

The study was conducted in three phases. Phase I consisted of an industry-wide profile of worker exposures in which a series of walk-through evaluations were completed, of typical operations including turkey, broiler, and egg production, hatcheries, and poultry processing. The objective of this phase of the study was to identify and quantify, on a geographical basis, the potential health hazards in various groups of workers.

Phase II consisted of a medical and environmental study of the worker groups identified in Phase I. A total of 257 workers (male and female) in poultry operations were studied. Participants consisted of 124 turkey producers and loaders, 92 egg producers, 26 broiler producers, and 15 workers in live-hang docks at processing plants (shacklers). A nonexposed group of 150 blue-collar workers (postal and electronics firm employees) were studied for comparison.

The following medical data were obtained from all participants: a) pre- and post-shift pulmonary function tests (PFT), b) pre- and post-shift CBC and differential, c) atopic status, and d) serum precipitins. Questionnaires were administered to document occupational and respiratory health history and presence of respiratory and general symptoms, and smoking status.

Environmental data were also collected at the work site and included sampling for personal and area total and respirable dust, endotoxin, ammonia, and carbon dioxide exposures.

Data analysis was conducted in Phase III of the study. Data showed that:

a) symptoms of bronchitis and ODTS were more prevalent among poultry workers than controls;
b) shacklers had the greatest prevalence of ODTS compared to other poultry workers;
c) poultry workers had greater decrements in forced expiratory volume in one second (FEV1), forced vital capacity (FVC)/FEV1, and forced expiratory flow (FEF) 25-75 over their work shifts than controls;
d) broiler producers had a greater frequency of symptoms of bronchitis and greater decrements in pulmonary function over their work shifts than other poultry workers.

Environmental data revealed highest personal total dust exposures in live-hang operations, and highest personal respirable exposures and endotoxin in broiler buildings. Personal ammonia exposures were highest in egg-laying operations.

Personal ammonia and endotoxin levels ranged higher in poultry operations than in swine confinement operations we previously measured in other studies.

Review of Literature

Farm workers have the highest percentage of disability due to respiratory conditions when compared to other industries (Haber 1971). Examples of respiratory conditions or agents that cause pulmonary illness in farmers include farmer's lung, atypical farmer's lung, occupational asthma, silo filler's disease, certain pesticides, certain infectious agents, and mineral dust (Popendorf et al., 1985). The innovation of confinement feeding in livestock production created a unique work environment resulting in a new set of respiratory illnesses that may become as important as all the previously mentioned agricultural respiratory conditions combined (Donham et al., 1977).

Confinement systems for livestock production exemplify modern, technological innovations to intensify production in agriculture. Confinement systems apply principles of mass production to livestock production, resulting in animals raised in high densities in structures which are totally or partially enclosed. The majority of swine and poultry confinement units are totally enclosed, increasing the potential for occupational health problems for those working in the buildings. Gaseous products from animal waste decomposition (including ammonia, hydrogen sulfide, carbon dioxide, and methane) or heating units (carbon monoxide and carbon dioxide) are released directly into the work environment. Levels of these gases inside swine confinement buildings often exceed Threshold Limit Values (TLV) (Donham and Popendorf, 1985). Aerosolized particles are a major human health hazard in swine confinement, with concentrations often exceeding the proposed TLV for grain dusts (4 mg/m^3) as well as the 10 mg/m^3 standard for nuisance dust (Donham et al., 1986).

While studying the health and the environment of people working in swine confinement buildings over the past several years, we noticed that approximately 12 percent of all workers experience asthmatic-like symptoms (Donham et al., 1989). An additional 60 to 70 percent report symptoms of bronchitis and 15 to 30 percent report symptoms of ODTS.

The number of people exposed to these hazards is substantial and growing. In 1977, we estimated that between one-half to one million workers were exposed to livestock confinement; of these, we estimated that between 156,000 to 210,000 are poultry workers. Meanwhile, the trend toward confinement continues to grow.

Since the poultry industry is dominated by confinement production, we anticipated that occupational hazards may exist for these workers which are similar to those found in swine confinement operations. In a pilot survey of 156 egg producers in 1980, we found that poultry workers did in fact have symptoms similar in nature and prevalence to swine confinement workers. Forty-nine percent reported excessive episodes of coughing; 35 percent reported excessive phlegm production; 35 percent reported scratchy throats; 42 percent experienced runny nose, and 48 percent reported burning and watery eyes. In a small environmental study, we found dust levels in confinement laying operations that exceeded the TLV for total and respirable nuisance dust. These data were very limited, indicating the need for larger controlled studies.

In the early 1980's, other researchers took an interest in poultry workers. Thedell et al., (1980); Olenchock et al., (1982); and Clark et al., (1983) found significant levels of endotoxin in dust from poultry buildings or live-hang operations. However, none of these studies examined health parameters. Several published clinical studies reported evidence of hypersensitivity pneumonitis among persons working with chickens or turkeys (Elman et al., 1968; Bar-Sela et al., 1984; Adila 1971). The only other reported study including health data was a small study by Thelin et al., (1984) in Sweden. In a survey of 47 poultry workers, coughing was identified as a significant symptom. Thelin also found significant decrements of lung function in one subgroup of these workers over a four-hour work period. Environmental levels of airborne dust were found in excess of the U.S. TLV.

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CONTROLLING FLIES THROUGH IPM AND OTHER PROGRAMS

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Fly control is an issue that gets the attention of every poultry producer when the level of flies exceeds an acceptable level. The fly threshold could be set by the producer, or the farm help who refuses to go into the building because of the flies, it could be set because of fly specks on the eggs or by the producers wife who is tired of having wrestling match with 1000 flies every time she wants to come in the back door. But in recent times, that threshold is being set by neighbors, some new, some not so new and is being set by either the threat of a court action or an actual court action. It may come in the form of a restraining order limiting bird number, restrictions may be placed as to when manure is cleaned out, how and if it is stored and where it is spread, in what field and when. To stay away of these types of public relations problems, fly control is elevated to a high priority, taking time from other tasks that involve the care of the birds and production issues. Fly control is looked at as an added portion of work for the day or week and only begun when flies are present. This is the wrong attitude. The place to start is to recognize that flies are a symptom of much bigger problems in the poultry facility!! These problems directly impact on bird performance, feed conversion, egg production all areas that impact on the profitability of the facility and these problems are present 12 months of the year.

WHAT PROBLEMS ARE FLIES SYMPTONS OF?

- Poor drainage around building
- Substandard ventilation in the building
  - fans not working properly
  - improper air movement
  - improper air flow
- Nutritional problems
  - salty water
  - extra salt in diet
- Poor insulation
  - difficulty in temperature mangement

Water quality problems
excessive water usage
Sub-standard construction
material quality (repair frequency)
Equipment failures
maintaining equipment

Buildings are constructed to maintain birds in an environment that will maximize production. Unfortunately, buildings last 20+ years and ideas on production, feeding and even the type of bird (and its specific needs such as temperature) change much more quickly. To maintain profitability, changes in average temperature, diet or equipment may have to be instituted. Some of these changes often produce situations that increase the chances of a fly problem, and in many cases, other options were available that could have solved the problem without creating another.

The importance of viewing the poultry facility in its entirety cannot be understated, and the fact that changes in one facet of it's operation may have large consequences in other areas of the facilities operation. To get a better understanding of exactly how one problem leads to another, let's examine the above list more closely.

Building Drainage

Building drainage is critical when discussing fly control. Wet manure will provide breeding areas for flies, it is just that simple. Wet manure will come from a variety of sources, but one source that can be minimized is from the removal of water from the poultry house site. This should start with a good analysis of surface water flow off the roof and away from the building. Water that is allowed to stay near the building will find a way under the structure and into the manure. Ditches and water ways are the most common techniques used to accomplish the needed redirection of water. In some cases, where little slope from one end of the building to the other is available, drainage tile can be used along the outer foundation of the building and even under a concrete floor to insure that water can get away from the building.

Building Construction

During the construction of the poultry building, many choices are made concerning the way the building is constructed and the type of material used in the building. Sub-standard materials do not hold up well and cause problems later as they fail and cause other systems within the poultry house to fail as well. As an example, insulation within the house is used as an aid in management of the environment to provide maximum production for the birds. If an insufficient amount of insulation is used, or if over time rodents are allowed to destroy the insulation, it will become difficult and costly to provide the proper temperature. A high-rise layer house with improper insulation and air leaks due to construction faults or material faults is a difficult house to maintain the proper temperature during the winter. To off-set this problem of temperature, the poultryman decreases the number of air exchange or turns off fans. While this helps with the winter temperature, it increases the level of moisture in the building. In some cases it seems like it is actually "raining" in the pit. This moisture is the result of poor ventilation of the respiratory moisture and should be delivered out of the building. But due to insufficient air flow, it remains in the building and is absorbed by the manure. When the temperature warms up in the spring, flies find much of the manure suitable for breeding. If the house is ventilated properly in the winter, production costs increase due to decreased production or increased feed costs. If ventilation is not done, money is spent with fly control in the spring and summer.

Substandard Ventilation

The lack of ventilation within the house is responsible for many fly problems. Without proper air flow, moisture cannot be removed from manure. Ventilation begins with the proper number of air exchanges for the building, that should provide the ideal environment for the birds. Fans and air intakes must be working properly. Air should enter the building only through designed air inlets. Air that is entering though other places (doors, holes in the wall, etc.) is not moved across birds and manure, cooling birds and then picking up moisture in the manure before it exits the building. If air is entering in the wrong place, the designed air movement scheme of the house will be corrupted. This leads to poor house environment and poor bird performance. All air inlets should be inspected at least twp times year to insure they are working properly. Air leaks should be sealed with the appropriate material. Side wall fans should be cleaned and inspected on a regular basis. During this inspection, the fan blades should be closely examined to determine if they are still in original condition. If they have flattened or been altered, air flow should be checked in front of each fan to insure that it is giving the proper output. Defective materials used in construction may contribute to poor air movement in and out of the house. To correct these deficiencies, fans may have to be added, moved or increased in size to off-set construction material and design flaws. Stirring fans in the pits can be used to increase air movement over the manure allowing the air to pick up the moisture in the manure, drying the manure to a point where fly breeding is not likely. These fans should be added to the pits so they can circulate the air in a circular fashion in the pit. It is also helpful to install them so they can come on in pairs so in the winter, only part of the fans can be used to aid in moisture removal.

Diet

Diet is also an important part of the total fly management picture. Water consumption should be monitored in each building throughout the year. Increased water consumption will require an increase in ventilation to remove this water from the structure. Increased water consumption can come from many areas, but diet and total salt intake are areas that should be closely monitored. Salt will come from the water source or the feed. If water consumption is on the high side, the water should be checked for salt level and this information provided to the nutritionist so it can be accounted for in the final diet balancing. Components of the diet can change as the price for components changes. Feed ingredients such as bakery by products may be high in salt and no other diet additives (such as a salt pack) will be needed to provide the required amount of salt and, in fact, the addition of the salt pack will increase the salt diet level and subsequently the water consumption.

Equipment Failures

Power Failures during storms, water line breaks as well as other types of equipment failures can lead to problems with manure moisture and fly breeding. Proper maintenance of equipment will reduce the chances of breakdowns that lead to wet manure and flies.

CONCLUSIONS

Fly management begins with the first evaluation of a site for a poultry house. If site preparation is not proper or if the design of the building is sub-standard, problems with pest management will plague the site for as long as it is in operation. Because of this, pest management on the site should be an ongoing program using all the principles of an IPM program. These include the use of biological control when available and pesticides when needed to maintain fly levels below threshold. Flies will always be part of any livestock production facility. They must be managed to insure that they remain below nuisance levels and to accomplish this we must work on fly management 12 months of the year, because how we manage the building in the winter may determine if we can manage the flies in July.

ZONING FOR ANIMAL AGRICULTURE: A PROACTIVE STANCE

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A survey was conducted to determine the extent of zoning for farm animal production in the eastern, midwestern, and southeastern portions of the United States and in California. The states included represented most of the poultry and egg industries. The differences in zoning regulations between states were very interesting. Regulations and authority to regulate come from as high as the state legislature or departments such as Environmental Quality, down to county and township zoning boards. Because of the very different manner in which zoning has been managed in the different states, counties and townships, a compilation of the different regulations and stipulations for the poultry industry is impractical. Therefore, the discussion in this paper will be directed towards the manner in which zoning has been approached in different areas of the country. Some procedures have been successful and some not as successful in writing positive ordinances that will allow for poultry industry growth and expansion into the next century.

There was one common thread in most of the information gleaned from the survey. If the animal industries are to survive and effectively expand into the next century, they must become very serious about how the various government units and activists view us. The industry should be thinking about the future and present themselves in a positive light. The methods needed to accomplish this task are all proactive. This is not to say that all of the suggestions given here will work in every situation. Areas for consideration are: defining agriculture, pro-actively supporting other animal industries, pro-actively requesting zoning and feasible setbacks, exhibiting environmental stewardship, establishing economic development and tax base knowledge, and establishing the value of green areas.

ESTABLISH THE DEFINITION OF AGRICULTURE

Some governing bodies are very pro-animal agriculture and some are not. Some states perceive agriculture as being only row crops. A good example of this is Tennessee where zoning has excluded animal agriculture in some instances. Agricultural lands should be available for agricultural uses and poultry is agriculture. If poultry housing is allowed to be called commercial or industrial, zoning regulations become much more restrictive. Sitings for processing plants, hatcheries, and feed mills come under a different heading. If in the zoning process, the definition of agriculture becomes a question and leads to legal involvement, the industry need only refer to Webster's New International Dictionary, 2nd ed. which gives the following definition of agriculture:

> The art or science of cultivating the ground, raising and harvesting crops, often including feeding, breeding and management of livestock; tillage; husbandry; farming; in a broad sense, the science and art of the production of plants and animals useful to man, including to a variable extent the preparation of these products for man's use and their disposal by marketing or otherwise.

Most courts live by the word of Webster.

SUPPORT OTHER ANIMAL INDUSTRIES

In many states, swine production and its associated odor problems has driven the agenda. All of the animal industries should be cooperative in defining the rules by which they will produce. A good case in point is North Carolina. The swine industry has been front page news many times over the past couple of years. Very restrictive regulations have been written for that industry. A few bad actors should not result in the swine industry having to operate under punitive regulations. What happens when the public and state or local governments decide that animal industry includes <u>all</u> animal agriculture and these regulations are applied to the poultry industry? This is a scary thought. When agricultural zoning ordinances are being debated for one portion of animal agriculture, all sectors should unite and take action. The poultry industry should support the swine industry in its struggle. This action allows the poultry industry to have input into regulations and ordinances which may one day be applied to them. Gaining gratitude from other animal industries should pay big benefits in the long run. And, the regulatory agencies may view poultry in a more favorable light.

REQUEST ZONING AND SETBACKS

If areas of production are not zoned for animal agriculture, this should be done. Getting government to zone for animal agriculture will help the poultry industry maintain their rights to expand within established areas of production concentration. Otherwise, the industry may realize a situation similar to that in Pennsylvania where strip development on road frontage is starting to become a problem by restricting animal agriculture ventures.

Setbacks are not all bad. A feed or live haul truck normally requires up to 100 feet to turn around. However, setbacks must be practical. Extremely deep setbacks can lead to very concentrated animal operation sites. A case in point is California. If a company is trying to site a new operation, land areas in compliance with all applicable rules, regulations, and setback restrictions are difficult to find. When land is located, there is an incentive to concentrate houses on that land. Since layer complexes are very concentrated, this can be a good idea, but concentration may not necessarily be good for broiler or turkey operations. In Texas, new layer facilities are setback at least one-fourth mile from property lines to avoid any future problems. The large setback results in a large area for manure disposal and avoidance of possible odor and fly nuisance complaints. This decision was made by the industry. Broiler housing is exempt from setbacks in Texas. However, the industry has become more proactive in siting broiler housing in areas of low risk from neighbor complaints. This action should help if zoning issues arise.

One manner in which to control zoning is to have it mandated at the state level and have consistent regulations for agriculturally zoned areas throughout the state. This would lend continuity and consistency. State regulated guidelines may help avoid a county by county or township by township ordinance writing effort. However, this can be a duel edged sword because one size may not fit all. This decision would have to be made on a case by case situation.

Established setbacks will help prospective operations avoid the horrors of the special use permitting process. The circus atmosphere created by the special use permitting process results from the necessity to solicit public comment in an open forum. This is a result of not having clearly defined agricultural zones and setbacks in an area. It is not enough that neighbors come and complain about potential animal operations, people from all over the county arrive to complain, even though their only standing is that they live in the county. The potential grower or poultry operation has very little chance for a favorable ruling. However, if the potential grower is in an agriculturally zoned area with established setbacks, there is no reason for publicity.

Several considerations must be made when siting a poultry facility. The new facility will increase truck traffic in the area and if not managed properly, the facility can affect ground and surface water quality as well as produce annoying fly populations and odors. Only the increased truck traffic is a certain consequence of a new facility. However, if new facilities are not properly managed, neighborhood groups from the surrounding areas could use the "bad actor" as an example to inhibit further placement of poultry facilities.

EXHIBIT ENVIRONMENTAL STEWARDSHIP AND GOOD NEIGHBOR RELATIONS

The economic performance of the poultry industry is cause for enthusiasm among its many beneficiaries. However, the increased expansion and growth has been accompanied by an increase in waste. Obviously, animal waste management is one of the keystones to a good regulatory and zoning environment. Therefore, the poultry industry must be vigorous in efforts to protect the environment and the quality of life of neighbors. Best Management Practices (BMP) and good neighbor policies are suggested in this case. Nutrient Management Plans (NMP) should be required of all growers and operations. Make sure that growers take the following items seriously. Never allow litter to get wet during storage. Avoid spreading litter when the land is too wet for immediate incorporation into the soil. Spread litter on land at agronomic rates. Retain litter disposal records for at least one year. Store litter in a covered fashion and no closer than 100 feet from perennial streams. Never spread litter on a windy day, especially when the wind direction does not enhance good neighbor relations.

As long as the farmer follows BMP, implements the NMP, and operates under generally accepted agricultural practices, a nuisance suit will be very difficult to bring to fruition. Nuisance complaints are somewhat of a puzzlement to the grower at times but this must be considered. It is amazing that in 1996 you must educate the masses that animal manures smell. It is ironic that many support "organic" farming but do not really understand what organic means.

The poultry industry must be concerned with where new facility sitings are allowed. Please remember, except for a few areas, residential and suburban areas are growing faster than the poultry industry. To survive as a viable entity into the next century, the poultry industry must avoid conflicts with its neighbors. It would be irresponsible to site a new facility near or within a developing residential area. Even if the new facility meets all existing ordinances, this facility may result in poor relations across the greater county area. Residents, realtors, activists, and regulators tend to congregate and consolidate power. This group is a powerful force in the complaint process and has been known to bring about the review and possible revision of existing ordinances. Virginia is a good example of this. Many zoning revisions have originated from the environmental concerns of neighbors. If surface water is contaminated during manure spreading or if flies hatch from the manure, trouble will come. Proper mortality disposal in an approved manner is essential. Even if pit disposal is legal, this practice should be discouraged before ground water problems are cited. If given a leg on which to stand, regulations will be forthcoming.

ESTABLISH THE VALUE OF FARMLAND TO THE TAX BASE

If county or township governments consider zoning to keep out potential animal agriculture operations, they must consider the economics. Without zoning to slow housing development growth, developments would overtake agricultural land and the tax base per unit would be exceeded by need within the new development quite quickly. Chickens and turkeys do not go to school and do not need the other services normally afforded new housing developments. New poultry operations usually target areas with an available labor force. If growth and expansion is stalled by unfavorable ordinances, these areas may suffer from a lack of the opportunities afforded by the poultry industry. American Farmland Trust (AFT) has published reports that indicate farmland is a net contributor to local coffers. This information dispels the argument that new residential development lowers property taxes for existing residents by increasing the tax base; and, that farmland gets an unfair tax break when it is assessed at its agricultural value instead of its potential development value.

The AFT conducted a study of the Purchase of Development Rights programs in Massachusetts and Connecticut. These states purchase farmland to preserve green areas within the state and prevent the farmland from being developed. The jury is still out on these programs. These reports and others that address farmland preservation techniques are available from AFT.

ESTABLISH THE VALUE OF GREEN AREAS

A county that tries to attract new industry and jobs will find that green areas and open spaces are important. If a county or township has a comprehensive growth plan, then areas for animal agriculture purposes should be clearly outlined. The county should have a plan to avoid strip development and other forms of haphazard building that encroaches on agricultural lands and creates problems. Knowing where development will occur can help the integrator know the areas to avoid when seeking new poultry housing sites. In agricultural zones, new residences must understand that farming is the major commodity in the area and that the farmers have a "right to farm". This must be in the deed to avoid future complications if at some time the new residents decide that they do not like the activities on neighboring properties. Farming maintains green areas and open space.

THE FUTURE OF THE INDUSTRY

When entering into zoning ordinance negotiations, the poultry industry must speak with a unanimous voice and include all other animal industries, if possible. In Virginia, there is a case where the poultry growers came to the zoning debate with rigid stances and varying views on what was acceptable. Because of the lack of unanimity, the expansion into this county has been retarded by setbacks of up to 1000 feet. To put this into perspective, the smallest piece of land that would accommodate a two house broiler operation with a 1000 ft setback would be a perfect rectangle with the dimensions of approximately 2,150 ft x 2,500 ft. The parcel would be approximately 123 acres. Any irregularities in the property lines would mean that this land would not meet the setback requirements. Therefore, only relatively large farms would be eligible for poultry house placement. This is not an attractive situation in many areas of the U.S. where small farms have been the life-blood of agriculture. With further cutbacks in support for many small grain and tobacco producers, these farmers will take steps to best utilize their acreage, stay profitable, and keep the family farm in the family. Therefore, a small family farm may become unsustainable unless an intensive livestock or poultry operation is added to the cash flow. If areas such as these are limited for poultry expansion and growth by unfavorable zoning ordinances, the historical small farm may become a thing of the past. The poultry industry does not win in this scenario.

CONCLUSIONS

In conclusion, the poultry industry must become very proactive in the establishment of positive zoning ordinances for animal agriculture. We must be good environmental stewards and neighbors. We must place ourselves in a positive light and pursue our opportunities. Without positive action, the poultry industry may be limited in its options for future expansion and growth.

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DEALING WITH LOCAL OFFICIALS AND OPPOSITION GROUPS: STRUCTURE, SIGNIFICANT TRENDS AND RECOMMENDATIONS

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The poultry industry is a model of quantitative efficiency. Whether measured in terms of feed efficiency, growth rate, yield, cost per pound, or numerous other factors, the production, processing and marketing of poultry has become the quintessential example of the application of scientific management to food production. Driven by these factors, the poultry industry is uniformly marked by highly intensive production and vertical integration. Nonetheless, while the economies of scale and size require industrialized production practices which are geographically concentrated, they also focus the associated by-products endemic to poultry production, e.g., waste, smell, disease, etc.

This paper will address the local political reactions among communities that are concerned with the side effects of poultry production. While poultry production undeniably contributes significant economic benefits to those communities, interest groups and local governments are increasingly ambivalent or adversarial in their relationships with poultry companies. Hence, the intent of this paper is to provide a brief framework which explains the history and trends of this political opposition. It begins with the historical rationale for opposition groups as contained in the First Amendment and continues with a discussion of significant political trends which promise to impact waste management regulations and relationships. The paper concludes that adversarial relationships between poultry companies and opposition groups are intentional and that they are getting worse. Finally, recommendations are presented to help companies co-exist and legitimize their decisions.

HISTORICAL JUSTIFICATION

Industry executives who must deal with seemingly endless regulations coupled with increasingly adversarial officials and citizens may feel frustrated by what they perceive to be a perpetual changing regulatory and public affairs landscape. Indeed, in managing poultry companies, consistency is essential in the planning and implementation of sound and profitable business policy. Nonetheless, the American political system is designed to encourage such frustrating politics.

The nation's founders correctly anticipated the emergence of the United States as an economic power. They believed that as America grew, large economic interests would materialize which would have the potential to dominate the political system. James Madison in particular took an ambivalent view toward the concentration of power in the hands of large economic interest groups (Berry, 1989). He felt that large companies would be naturally inclined to impose their particular beliefs upon the general citizenry, often against its will. He was also anxious at the prospect of centralized governmental power residing in Washington, D.C., or any other seat of power. He believed that such centralized governmental power would favor the large economic interests at the expense of the general public. Subsequently, Madison expressed this fear of large economic interests and their potential political dominance by creating a federal republic whereby power was to be decentralized and vested in the hands of interest groups. Best expressed in Federalist #10 and Federalist #51, the founders argued that a political system was needed which would encourage adversarial political groups who would fight out their differing beliefs primarily at the state and local level (Berry, 1989).

What does this digression into political history have to do with the poultry industry? The regulatory and adversarial landscape that poultry companies see before them is the direct and intended descendent of the political system that is intended to be adversarial, it is intended to be characterized by a seemingly endless array of checks against power, and it is intended to be marked by the emergence of countless citizen interest groups who oppose virtually every policy. Indeed, the system is designed to be as frustrating as possible, and in so doing frustrate the ability of strong economic interests such as poultry companies to run roughshod over the interest of the minority. Although industry executives may see themselves (perhaps correctly) as acting in the "enlightened self-interest" envisioned by John Locke whereby good business practices go hand-in-hand with good corporate citizenship, James Madison held a somewhat darker view of human nature. In his view, large interests such as corporations could not be trusted to act with magnanimity and reserve; rather, their selfish interest would be contrary to the public good (Berry, 1989). While providing little solace for poultry managers who must do political combat on a daily basis, our political system is such that those managers have no choice but to participate in adversarial politics.

Thus far the paper has discussed the rations for adversarial politics. Fearing the domination of politics by large groups, the founders created a system which encouraged a multiplicity of countless interest groups to frustrate the large groups. Fearing that centralized power would readily lend itself to domination by those same large groups, the founders created a federal system whereby power would be diffused outward to states and localities. Hence, when faced with such a cacophony of various and as sundry interest groups operating at all levels of government, large interest groups, e.g., poultry federations, could never control policy. Therefore, the paper has argued that the system which confronts the poultry industry is wholly deliberate and intended. In the next section, the paper examines significant changes in the evolving American political landscape and argues that poultry managers should anticipate an increase in the number and size of the groups that oppose them, an increase in the power of those groups, and an increase in those groups' ability to frustrate the poultry industry.

CURRENT TRENDS

The solution to the centralized abuse of power as intended by the founders was dissemination of power throughout the republic and the creation of countless interest groups all vying for control of policy. Their system has succeeded beyond their wildest dreams. What was to them a struggling republic has evolved into a political system more closely resembling a true democracy where a political free-for-all rages in quasi-anarchical fashion. In other words, poultry industry managers confront a political system where almost any voice can be heard, regardless of its credentials or literacy (Westra and Wenz, 1995).

Having established the legitimacy of federal government as well as the intended necessity of opposition groups and adversarial politics, the paper now examines significant trends in the American polity which bear direct influence on the poultry industry. These factors include a public which is affluent, better informed, highly educated, technologically competent, and increasingly atomized and individualistic (Lunch, 1987; Berry, 1989; Westra and Wenz, 1995).

Increased Affluence

It has been said that environmentalism is a disease of success....to put it another way, only those cultures that reach a certain level of material affluence are able to turn their attention from subsistence to quality of life issues (Westra and Wenz, 1995). First articulated in Maslow's Hierarchy of need, this concept indicates that as affluence increases, so does interest in things like politics and policies. Although the validity of such deterministic theories has been attacked, the emergence of opposition mass movements like environmentalism and the women's movement can certainly be linked to increasing levels of affluence (Lunch, 1987). This is to say that the poultry industry faces a populace that has the financial and time resources to become interested in waste management policy.

Better Informed

Social Science data indicate that the general public is increasingly well informed about issues which both indirectly and directly affect them (Lunch, 1987). Traditionally, policy such as waste management was captured within policy sub-governments whereby experts from affected industries, legislators from the industry's district or state, and regulators from the industry's associated federal and state bureaucracies formed policies in a consensual fashion (Berry, 1989). For example, western ranchers, Congressmen from western states, and officials from the Bureau of Land Management would form grazing policy in a consensual fashion. This was partly a function of the required level of information necessary for both to understand, and be interested in, esoteric policies. Nonetheless, with the advent of mass media, and television in particular, highly complex and esoteric policies have gained wide exposure to public scrutiny. Whereas historically only westerners would have been exposed to grazing policy, with the advent of mass communications people around the country now know that cattle range on western public lands at greatly subsidized rates. This exposure, although arguably highly simplistic and generalized, nevertheless has proved a modicum of information to interested citizens where none had existed before. While it can be argued that the American public knows more and more about less and less, it is undeniable that policy discussions like those relating to waste management have been directly influenced by the ability of mass media to rapidly disseminate information about the benefits and effects. This information dissemination has served to widen the circle of parties interested in policy formulation.

Highly Educated

Social science data also demonstrate that the American people are increasingly educated. This increasing education has accomplished at least two results: increasing comfort with complex issues, and more importantly, increasing confidence in the individual's ability to make rational choices without outside expertise (Lunch, 1987). With the advent of mandatory education and the widespread availability of college, citizens are exposed topics like waste management. If a little knowledge is dangerous, than the American people may be among the most dangerous in the world. This is only partly facetious; as citizens become better educated, their ability to sift, analyze and interpret various policy options tends to increase their opposition to policies which would have traditionally been implemented without general review.

Perhaps most important, demographers indicate that as education levels increase, citizen interest in politics trend to similarly increase, particularly in situation-specific instances where policies directly affect highly educated citizens. In other words, education is a process whereby citizens are inculcated with a rational method of determining choices. This is not to say that people make rational decisions. Instead, increased education diminishes the population's dependence upon Authority (Divine or otherwise) and Expertise to make decisions. Hence, in the case of waste management, citizens become less and less dependent upon "experts" and more and more dependent upon their own decision making process. Thus, the increasing educational level of the American public has caused an increased interest in waste management policy within the affected communities.

Technologically Competent

A fourth related phenomenon which directly influences waste management policy is the increasing technological competence of the American public. Once again, this is not to say that the public is competent about specific technologies, e.g., composting and non-point source pollutants. Rather, the public is increasingly comfortable with the idea of seeking out esoteric information with which to geed their particular biases (Lunch, 1987; Berry, 1989). Indeed, the advent of rapid-dissemination technologies such as the world-wide-web has democratized information about areas which were previously the exclusive purview of policy wonks (Taylor, 1995). In other words, information about waste management has become readily available to anyone able to access the web. Likewise, the advent of direct mail as an opposition group political mobilization tool has serves to bring a level of technological competence within reach of the general public (Taylor, 1995). In effect, opposition groups now have the technology to take their particular version of the facts before a wider audience, and thus attempt to gain widespread support for their policy.

Atomized and Individualistic

Perhaps the most profound trend is the American public's increasing level of individualism and atomization (Wildavsky, 1992). Traditionally, citizens vested "experts" with extensive implicit authority to a make decisions. Based upon the republic concept of the social contract, citizens understood that "authorities" and "experts" would act in their best interest or would be punished for failing to do so. This understanding of the authority and accountability of experts has largely eroded (Wildavsky, 1992). In its place the concept of the individual as the sole source of legitimate authority has ascended to preeminence in the American political ethos. Endless social critics have commented on the rising individualism of the American public, and even more have noted the seemingly atomized nature of the polity. From the Lonely Crowd to habits of the Heart, social scientists have noted a disturbing trend amount among the American public away from reliance upon community decision making processes and toward individualistic decision process. Indeed, evidence indicates that people ware trusting less in traditional communitarian decisions and trusting more in themselves (Wildavsky, 1992).

To put it another way, the tradition of public consensus arising from a commonly accepted "fair and legitimate" process has largely been displaced by a culture of complaint where any individual who feels spited by the outcome of a community decision feels empowered and entitled to seek redress of his or her grievances. Indeed, no person can be expected to be an expert on many issues. Hence, highly specialized experts were traditionally vested with extraordinary trust and authority to make decisions. This included the area of waste management. However, citizens who are highly individualistic are less likely to place their trust in "experts" and are less likely to trust the outcome of a communitarian, democratic policy process which negatively affects them.

CONCLUSION AND RECOMMENDATIONS

Thus far the paper has examined the political framework within which poultry companies and waste management policies must operate. The political system is intended to be confrontational, it is intended to be frustrating, and it is intended to diffuse power. To protect the rights of individual citizens in the face of anticipated tyranny by strong interest groups and economic coalitions, the founders established a system where many opposition groups would be vying for policy preeminence at once, creating a cacophony of wildest dreams. We arguably live in the most democratic era in our nation's history. A plethora of groups vie for attention on countless issues, and affluent individual citizens have previously unheard of access to information, education, and technology, all of which increase their ability to have their voices heard.

What does this mean for poultry companies confronting waste management issues? First, managers should accept the inevitably of political conflict over the most mundane and trivial policy issues; indeed, the political system is designed to operate in exactly this way. Second, managers should expect an increase in the amount and intensity of conflicts over various policies. For reasons of increasing affluence, information, education, and technological competence, citizens who once were complacent in accepting centralized, authoritarian policies are placing decreasing legitimacy in decisions derived from such processes. Third, the single ascendent political ethos of American culture is the Individual and his or her perceived entitlement to participate in, and thus alter, even the most obtuse and esoteric policies. This includes waste management. Hence, managers should anticipate greatly increased frustration as individual citizens, through use of various technologies, not only become interested in waste management but attempt to alter or stop specific policies. Finally, managers can expect two general responses from the local community; apathy and antipathy (Lober, 1995). Attitudinal and behavioral responses of people living in proximity to waste sites generally differ along these two lines, and managers should pay careful attention to the source and outlet of each set of responses.

As for local officials, George Washington said that Congress is a mirror of the people's will. What can be said of politics at the federal level is even more true of politics at the local level . . . Tip O'Neill often quipped, "All Politics is local". Thus, in dealing with local officials, managers should pay particular attention to explicit and implied political agendas of the officials, and track public opinion regarding various issues. In other words, managers must play the political game at the local level, being careful to discern and react to elite opinion. In the case of waste management, managers should assess the opinion of local elites and citizens prior to the emergence of waste management as an issue. It is beyond the scope of this brief review to discuss a method for alleviating the pressures of these changes. Nonetheless, companies should remember that the same representative system that frustrates them also provides relief. The critical element of Democracy is Ligitmacy . . . representative political systems are marked by a process whereby the outcome is granted legitimacy by participants because each person has equal theoretical access to, and influence upon, the outcome. Hence, poultry companies should emulate their political system and its public agencies in an attempt to gain legitimacy for their waste management decisions. Remembering that the political process is intended to be frustrating to economic interests, and remembering that citizens are becoming increasingly adversarial about their presence, they should do their groundwork in advance of actual political battles. They should build consensus and identify both potential opponents and proponents through scoping processes and public hearings. In this approach, companies go into a community and seek community input prior to reaching a policy. Through a series of public hearings an focus groups, the company partially legitimizes its decisions. And although individuals may remain adamantly opposed to the outcome, the company can shroud itself in the democratic process. And in so doing, they create a process which partially vents the opposition.

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INTERACTING WITH LOCAL COMMUNITIES AND NEIGHBORS

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I appreciate the opportunity to talk to you today. I want to tell about the way we approached revising our waste management plan and our whole Waste Management Practices for a commercial egg operation.

The operation we have is one million commercial layers that is company owned and is high-rise housing all on one site. The site was burned at one time and then built back in concrete to prevent a second burning. There is a processing plant and coolers and we distribute eggs into North and South Carolina.

Until then, we were operating with limited success as far as our management of manure. The farm had a history of complaints as far as odor and flies coming from the farm itself and where they took the manure. As a result, our relations with DHEC of South Carolina were not the best. The reasons we had the problems were leaky drinkers for one. the manure never had a chance to dry out. the manure was never dry enough or wet enough to limit fly breeding. Downstairs, where the manure was kept, had a lack of air movement. We never had a definite plan where the manure was to go or how to go. We had a lot of wet manure and a lot of flies in the manure. We were spreading with a honey-wagon. So four years ago, we decided to be responsible about handling the manure. We wanted to control our flies, wanted to control when we disposed of our manure, and needed a long term plan to make our manure a by-product, asset not a liability.

First, we decided to go dry and dry up the manure no matter what. Cal-Maine worked with us to change our the old Hart cups to the new Hart cups, and we got a leak detection program. We got a fellow extensionist, Mike Czarick from Georgia to improve our ventilation. We put in some stirring fans and improved out inlets and baffles and increased the air flow over the litter. We cleaned all our litter out completely and then we could take the dry litter out whenever we wanted. We purchased a little tractor to take care of leaks and wet areas to keep the manure dry in the pit. We had no mass spreading of liquid manure on hayfields to eliminate the public perception of Cal-Maine. We started working with one large farmer that would be able to handle all our manure. He was responsible and took soil samples, and used our information to develop a cropping scheme.

Shortly after we put these practices in place, DHEC wanted us to review our waste management plan. We went to Jesse Grimes who helped find an engineering firm to organize a waste management plan. They reviewed our procedure and met with DHEC and found what they needed and put in a workable waste management plan. It compared year to year analysis of the manure, comparison of soil samples and what crops that are to be grown in order to balance the nutrients.

I feel the key is that if you have to put some plans together, you need to meet with the state environmental people and see what your plans and intentions are. Then you have to execute the plan to limit exposure of odor and flies. That's why we move our manure only in the fall and Winter to have the least chance of disturbing our neighbor's cookouts and when flies would move.

We use a local renderer to take our dead birds. If they don't, we think we will go to composting our dead birds. We are producing egg wash waste water, but this is not that great of volume and is adequately handled with lagoon system.

One of our other by-products is our spent hens. Fortunately, we still have some processors to take our spent hens, but that is an opportunity in the future. Maybe rendering or composting will be the future for spent hens.

ODOR ABATEMENT: CASE STUDIES OF THE SWINE INDUSTRY

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During the past decade, much change has occurred in the composition of North Carolina's agriculture. Due to growth in the state's swine and poultry industries, revenues from animal agriculture now exceed those of crop production to reverse the historic relationship of these two sectors. Between 1991 and 1995, the NC swine inventory increased from 2.7 million head to 7.5 million head. Most of the growth occurred in southeastern North Carolina; in some southeastern counties the ratio of pigs to people is estimated to be approximately 30:1. The economic benefits realized by the growth of the swine industry in these counties, and the State, has been significant (Murphy and Hayes, 1994). However, concerns and complaints associated with the increased volume and management of wastes accompanying the growth of this industry has also been significant.

Concerns about the environmental impacts resulting from the rapid growth of the State's swine industry resulted in legislation in both the 1993 and 1995 Sessions of the North Carolina General Assembly. The primary focus in 1993 related to odor abatement issues (North Carolina Agricultural Research Service, 1995). A lagoon failure in June of 1995, in eastern North Carolina, that resulted in the release of several million gallons of liquid swine manure into the New River focused the public's attention on water quality issues. Subsequently, the Blue Ribbon Study Commission on Agricultural Waste was created by the 1995 North Carolina General Assembly to study "the effect of agriculture waste on groundwater, drinking water and air quality". Although the bill specifically noted "agriculture waste" as its topic, there was little doubt that the driving force behind the establishment of the Commission was the rapid growth of swine production in the State, as well as the lagoon failure referenced above. The majority of the documents reviewed, testimony heard, and recommendations made by the Commission centered around swine production practices (Blue Ribbon Study Commission on Agricultural Waste, 1996). However, North Carolina is not unique in its attention (and opposition) directed to the livestock industry in general and the swine industry in particular. Several states are considering regulatory changes that have the potential to significantly impact the future of animal agriculture. Much of the increased focus on animal agriculture can be attributed to the urbanization of traditionally agricultural areas and the resulting conflicts between food-animal producers and the general public regarding odor issues. In many areas, nuisance concerns associated with odor may impact the sustainabilty of animal agriculture more so than water quality issues. There is little doubt that alternative strategies for mitigating the impact of odors released during the production, storage, treatment and/or land application of manures will be required in the future.

In an effort to address these environmental concerns, many odor-abatement technologies are currently under development, some of which have only been tested at the laboratory bench and/or under pilot-scale conditions. Some of these technologies include: packed bed dry scrubbers (Miner, 1981); soil filters (Bohn, 1972; Kowaleswshy et al., 1979); floating lagoon blankets (Miner, 1995a); biofilters (Naylor and Kuter, 1990; Allen, 1995); manure and/or feed additives (Williams, 1995; Williams and Schiffman, 1995); aeration (Goodrich et al., 1995; Miner, 1995, Westerman, 1995); anaerobic digestion (Wilkie, 1995), and; incinerators, condensers, and catalytic converters (North Carolina Agricultural Research Service, 1995). However, many of these technologies are not considered to be technically or economically feasible for most livestock and poultry operations. Further research and development, as well as outreach demonstration of their economic and environmental benefits will be required prior to their wide spread utilization by the animal production industries.

SWINE ODOR ABATEMENT STUDIES

During the previous 2 years, collaborative (and independent) efforts by the North Carolina State University Animal and Poultry Waste Management Center (APWMC) and the Duke University Medical Center Taste and Smell Laboratory have been underway to evaluate various odor abatement technologies and/or products. To follow is an overview of some results to date.

Odor Abatement Products: Laboratory-Scale Evaluations

Many swine producers are considering the use of commercial manure and/or feed additives in their efforts to abate or control odor. These additives can generally be grouped into one of several categories based upon their mechanism of action. Ritter (1989) identified six categories of odor control products: masking agents, counteractants, digestive deodorants, adsorbents, feed additives, and chemical deodorants. Of the numerous odor control products available, it is likely that some, under the appropriate environmental and management conditions, may be effective for reducing odor intensity and/or improving odor quality. However, it is also likely that many may prove to be ineffective. For this reason, scientific information regarding the efficacy of commercial products for odor control is needed by livestock producers.

Several researchers have reported on the performance of odor control additives that were evaluated under laboratory and/or field conditions. An overview of the literature regarding the effectiveness of odor control additives in the form of: bacteria and enzymes, oxidizing agents and germicides, masking agents and counteractants, adsorbents and absorbents, inorganic chemicals, and sarsaponin was reported by Williams (1995). However, as noted by Miner et al. (1995), such investigations are hindered by the lack of a standard procedure for the evaluation of odor control additives. To address this problem, cooperative efforts were established between the APWMC, other universities, commodity groups, and commercial enterprises to establish a testing procedure and reporting format which can be used to provide consistent odor product information for food-animal producers and processors. The protocol described by Williams (1995) was developed through these efforts and has been utilized by the APWMC to evaluate the effect of several products on odor intensity, odor irritation, odor quality and other environmental parameters associated with swine manure.

Results of some initial evaluations comparing 5 different additives (counteractant, oxidizing agent, absorbant, chemical deodorant, and digestive deodorant) were reported by Williams and Schiffman (1995). These studies showed that of the 5 products tested, odor intensity of the manure slurry was significantly reduced by the oxidizing agent (potassium permanganate). Irritation intensity was not suppressed by any of the additives tested. Only the counteractant and the oxidizing agent were shown to significantly improve odor quality. In addition to these results, several evaluations of chemical and/or digestive deodorants have been completed in the APWMC laboratory during the past year. Under the conditions tested, few have shown any significant improvement in odor parameters as measured by the odor panel evaluations.

Based on the collective results of our laboratory evaluations to date, the "track record" for odor control additives is not encouraging. In general, these results are consistent with data in the scientific literature. However, some of the manure additives have shown to significantly abate odor from liquid swine manure. It is recommended that such additives be further evaluated under commercial scale conditions to 1) validate their efficacy of odor abatement and 2) determine their economic feasibility for effective odor reduction. Currently, the APWMC has several evaluations in progress (laboratory and commercial-scale) for a variety of odor abatement products/technologies.

Odor Abatement Products/Technologies: Commercial-Scale Evaluations

Microbial Additive: Some swine producers in North Carolina are incorporating, on a trial basis, commercially available products and technologies marketed for odor control into their on-site operations. Based on odor abatement results previously observed during an independent 3 month evaluation of a microbial augmentation product, one principle producer initiated a subsequent controlled study of the product under the direction of the APWMC. The experimental design is described in Table 1. Measurements of odor perception were evaluated at the Duke University Medical Center Taste and Smell Laboratory by a trained odor panel (panelist were residents of North Carolina and ranged in age from 26-47 years; none lived near swine operations). Samples for odor analysis were collected by 2 different methods: 1) odors from inside the swine finishing houses and immediately down wind from the lagoons were absorbed (1-hr exposure)onto cotton fabric swatches as described by Licht and Miner (1978) and Williams and Schiffman (1995), and 2) aqueous samples were collected directly from the lagoons. In all experiments, odor panel evaluations occurred in the afternoon or evening of the same day that odor samples were collected. The odor panel was comprised of 10 individuals and, in general, the same panelists were utilized for all analysis. Each panelist was presented a separate bottle and instructed to rate odor intensity, odor irritation, and odor pleasantness on a 0-8 scale as shown in Figure 1. To minimize the potential of odor fatigue, the number of odor samples evaluated on any given day did not exceed a total of 30.

Results show that after 90 days of the microbial treatment, odor intensity had decreased by approximately 40% and the odor quality rating had improved from "moderately unpleasant" to "neither pleasant nor unpleasant" (neutral) in the finishing houses (Figure 2A). However, similar results were also measured for the finishing houses receiving no augmented microbial treatment (Figure 2B). Odor irritation was not measured to exceed a rating of "weak" for the treated or untreated finishing houses during the same period. Air samples collected down wind, less than 3 meters from the lagoon's edge, showed similar trends (Figures 3A and 3B). Odor intensity decreased by approximately 50% for both treated and non-treated lagoons, whereas odor quality, originally measured to be slightly unpleasant at Day 0, improved to a neutral rating for both lagoons. Odor analysis of the lagoon contents (aqueous samples) showed that, as compared to Day 0 baseline values, odor intensity significantly ($P<.05$) decreased for both the treated (18% decrease) and non-treated lagoons (15% decrease) by Day 90 (Figures 4A and 4B). During this same treatment period, odor quality ratings for the aqueous samples, initially characterized as "very unpleasant", improved by 13% for the treated lagoon as compared to a 7% improvement in the lagoon receiving no augmented microbial treatment. This represented an improvement to the "moderately unpleasant" range for both lagoons.

Blank samples (cotton swatch baked at 85 C° for 1 hr and exposed to no odorants) showed essentially no odor presence for all experiments (Figure 5). The positive control samples (20 μl butyric acid added directly to the cotton swatch) were consistently evaluated to be extremely intense in both odor concentration and irritation and extremely unpleasant in odor quality (Figure 6).

<u>o-dichlorobenzene</u>: In a separate experiment, and on separate swine farms, a chemical deodorant described as 80% o-dichlorobenzene and 20% organic emulsifiers was evaluated for its odor abatement capacity by the Duke University Medical Center Taste and Smell Laboratory. The liquid chemical was diluted at a rate of approximately 500 ml per 30 l water for spray application per 10 sq m of treated surface area. The product was also added to the building flush tanks for "preventive maintenance." Odor samples from inside the swine facility were taken at Site #1 at times 0 (just prior to application), 2 hours, and 6 days post application. Site #2 (separate farm) received the same application and odor samples were taken at times 0 and 6 days post application. Results for Site #1 showed that 2 hours post application, there were decreases in odor intensity, irritation intensity, and unpleasantness ratings by 12%, 28%, and 14%, respectively (Figure 7); however, Day 6 results showed that values for all 3 odor parameters were essentially the same as measured prior to the initial application of the product (Figure 7). Results for Site #2, shown in Figure 8, also indicate that marginal differences were measured 6 days after the initial application of the product.

Ozone: Ozone, an oxidizing agent frequently used in wastewater treatment application for odor control, was also evaluated by the Duke University Medical Center Taste and Smell Laboratory. The experiment involved utilizing an ozone generator to introduce the chemical throughout the swine facility at a concentration of 0.8 ppm (as determined by Drager tube analysis). Odor samples were collected within the house and from the exhaust fans at the treated facility and an adjacent facility receiving no treatment. The number and ages of the animals within each facility were approximately the same. Results, as evaluated by the odor panel showed no detectable difference between the ozone treated and the non-ozone treated house (Figures 9 and 10).

SUMMARY

The North Carolina pork industry has experienced rapid growth and much improved productivity during the past decade. As a result, the industry has also experienced increasing concerns regarding odor control. Many producers are using, or considering the use of, various technologies for odor abatement. Although numerous odor abatement products and technologies are commercially available, few have been evaluated under objective conditions. The experiments reported herein evaluated various odor abatement products under laboratory and/or commercial-scale conditions. Controlled laboratory analysis showed: 1) that a neutralizing agent improved odor quality, 2) an oxidizing agent reduced odor intensity and improved odor quality, and 3) an absorbent, digestive agent, and chemical deodorant did not significantly improve odor parameters under the environmental conditions tested. Controlled commercial-scale evaluations showed that a microbial product, and the chemical o-dichlorobenzene had marginal effects on improving odor parameters. A case study showed that ozone had no significant effect on odor abatement.

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Table 1. Experimental Design. Commercial-Scale Evaluation of a Microbial Odor Abatement Product.

Parameters	Treatment	Control
Recycled lagoon water	yes	yes
Microbial product	yes	no

Treatments and controls consist of 4 finishing houses each (880 animals per finishing house). Treatment and Control facilities discharge (pit recharge system) to separate lagoons (approximately 700,000 cubic feet each). Treatment lagoon received the microbial product (approximately 25 kg) on Days 0 and 7; Treatment finishing houses received the microbial product (approximately 3 kg per house) on Days 0, 7, 21, 28, and approximately 0.5 kg per house weekly after Day 28. Sampling frequency for odor parameters (within the finishing houses and at the lagoons) = approximate 30 day intervals.

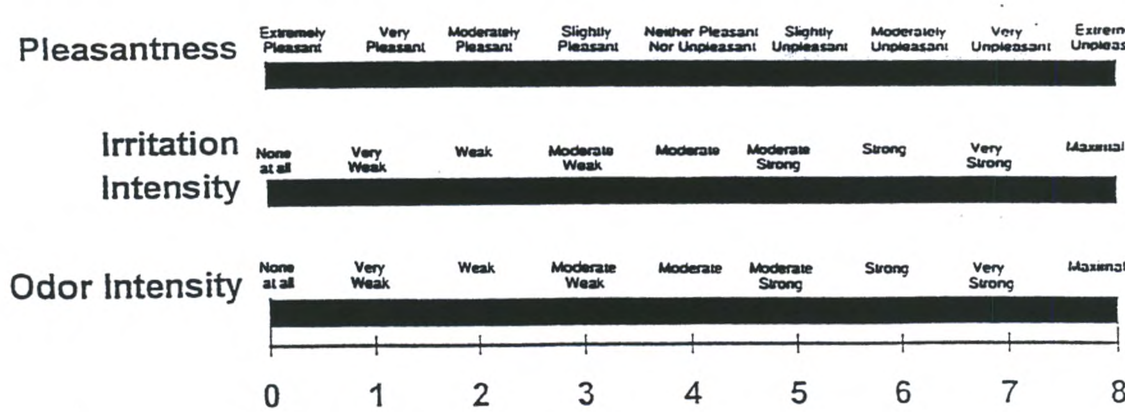

Figure 1. Descriptive scales for odor intensity, irritation intensity, and pleasantness utilized by odor panel members.

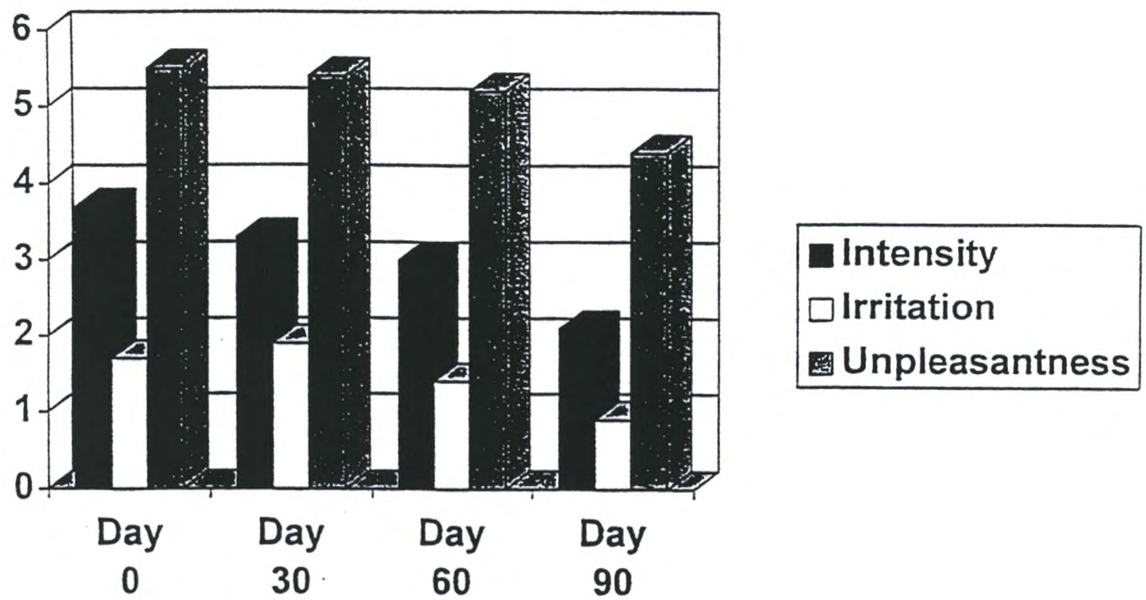

Figure 2A. Odor perception results. Air samples collected from finishing houses receiving microbial treatment.

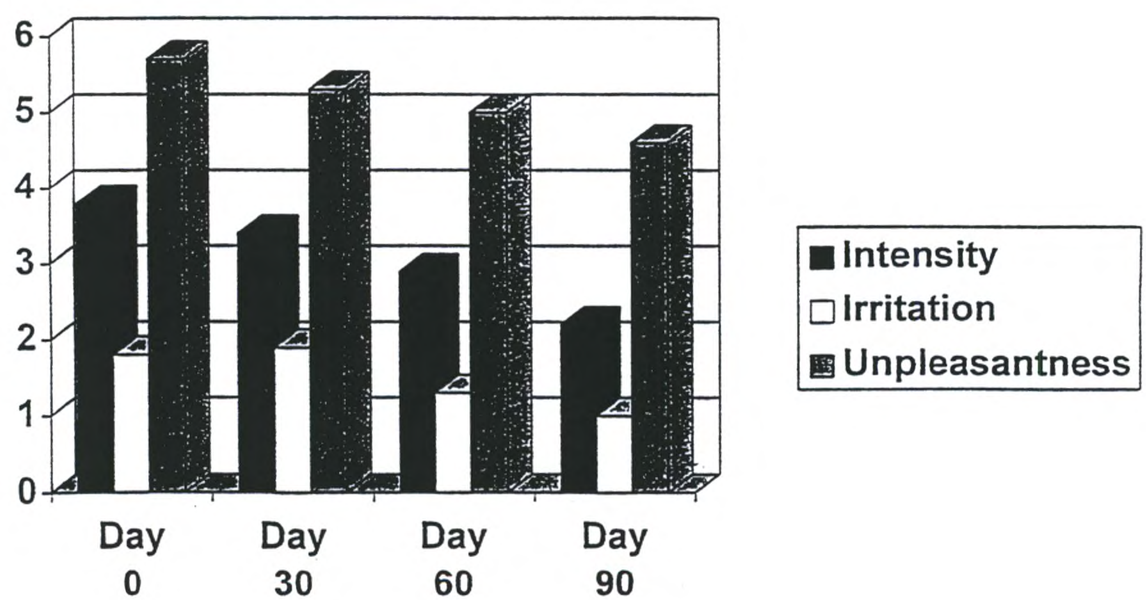

Figure 2B. Odor perception results. Air samples collected from finishing houses receiving no augmented microbial treatment.

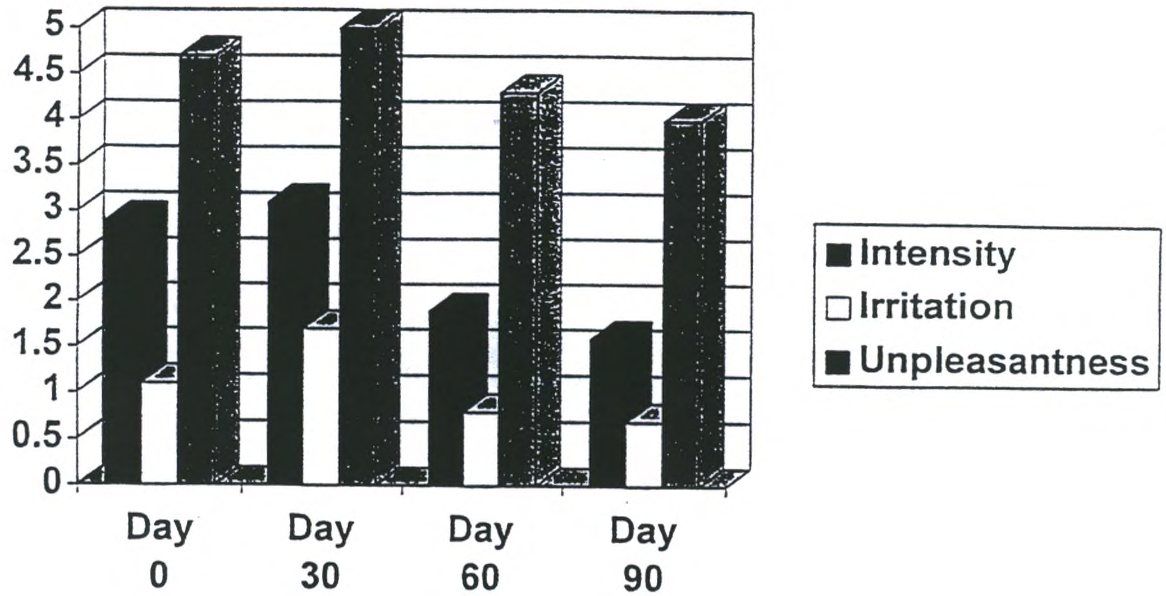

Figure 3A. Odor perception results. Air samples collected at lagoon receiving microbial treatment.

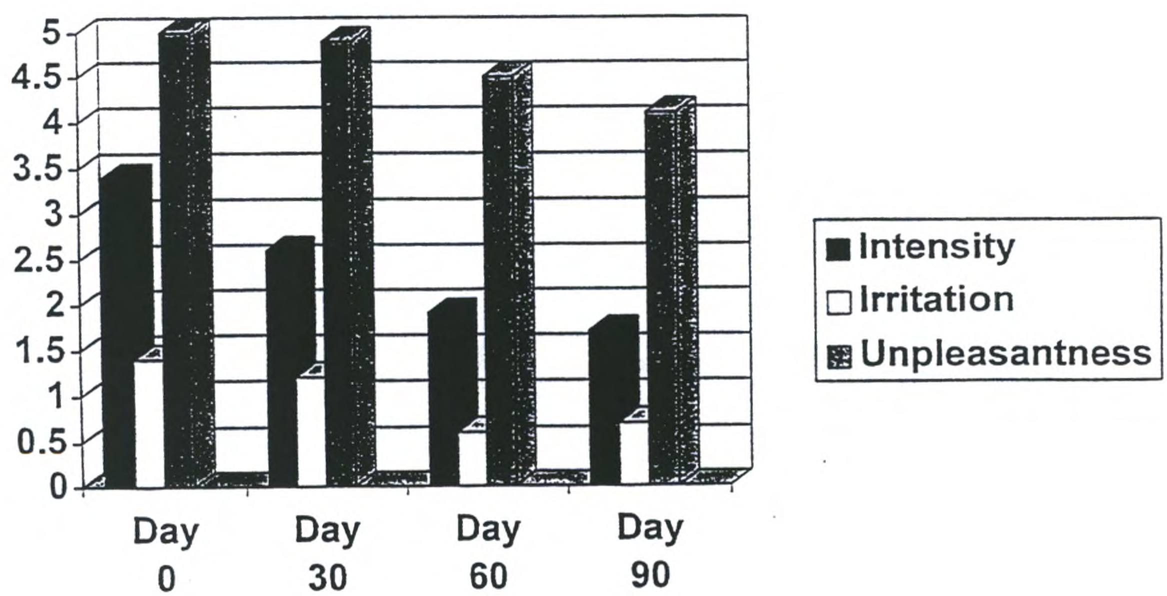

Figure 3B. Odor perception results. Air samples collected at lagoon receiving no augmented microbial treatment.

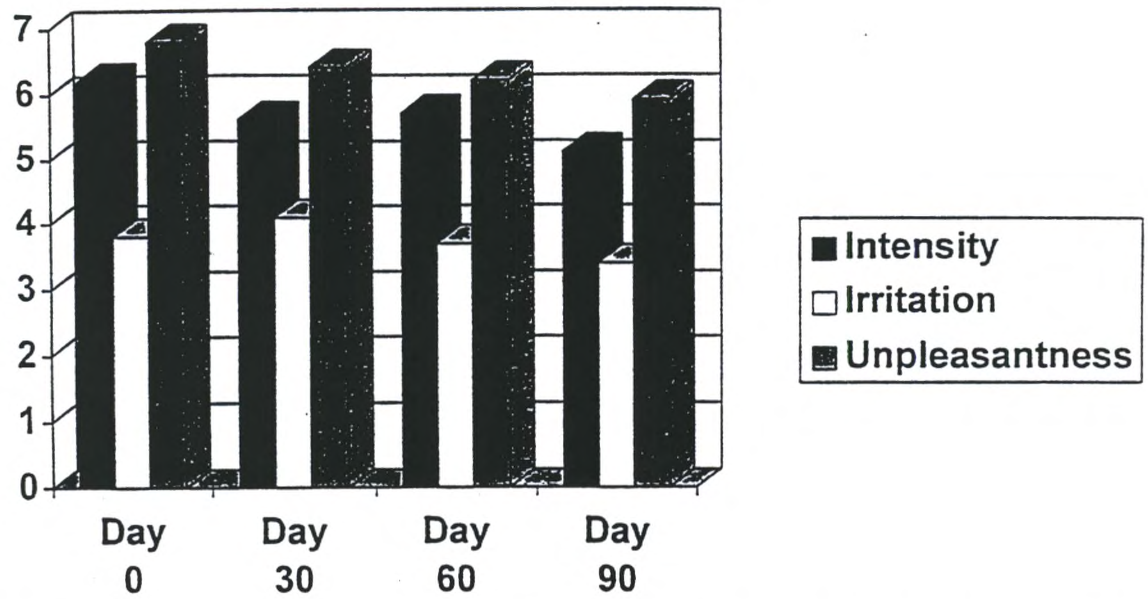

Figure 4A. Odor perception results. Aqueous samples collected from lagoon receiving microbial treatment.

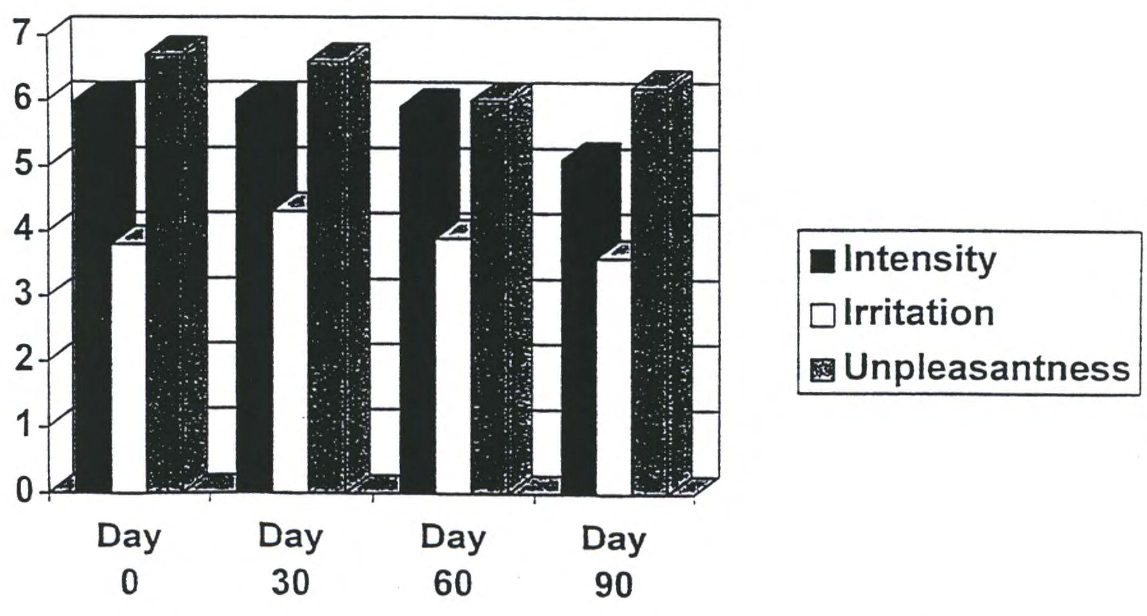

Figure 4B. Odor perception results. Aqueous samples collected from lagoon receiving no augmented microbial treatment.

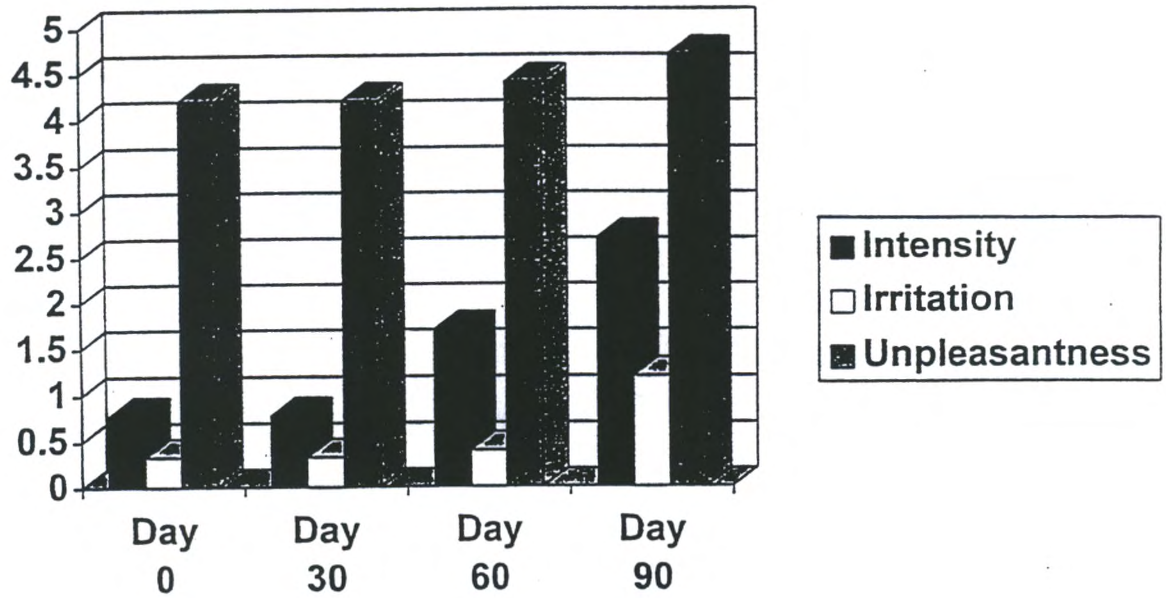

Figure 5. Odor perception results. Blank samples.

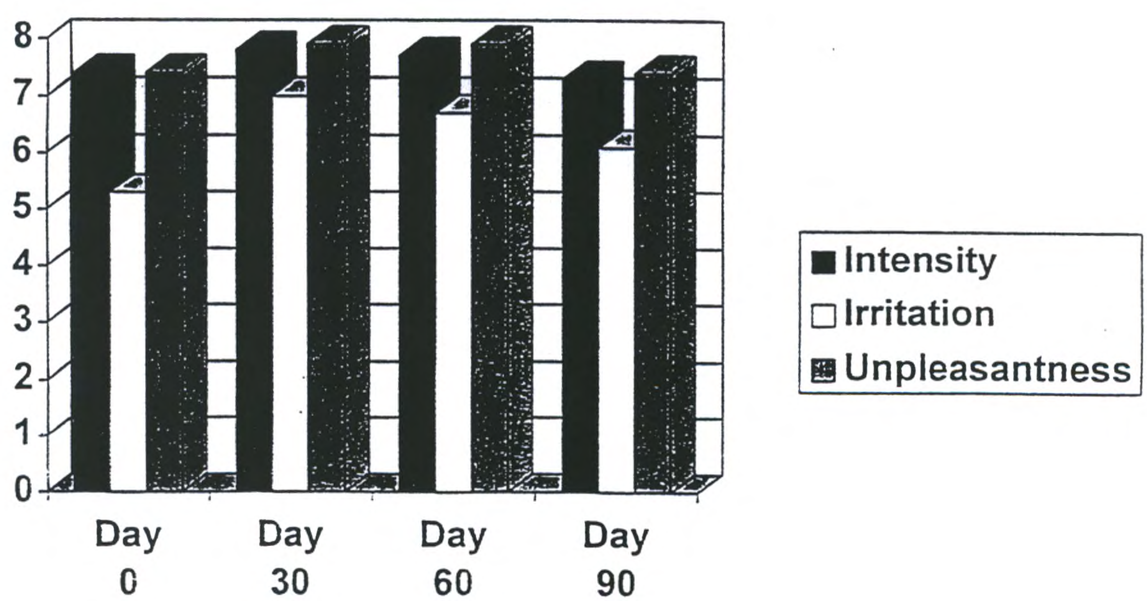

Figure 6. Odor perception results. Positive control samples.

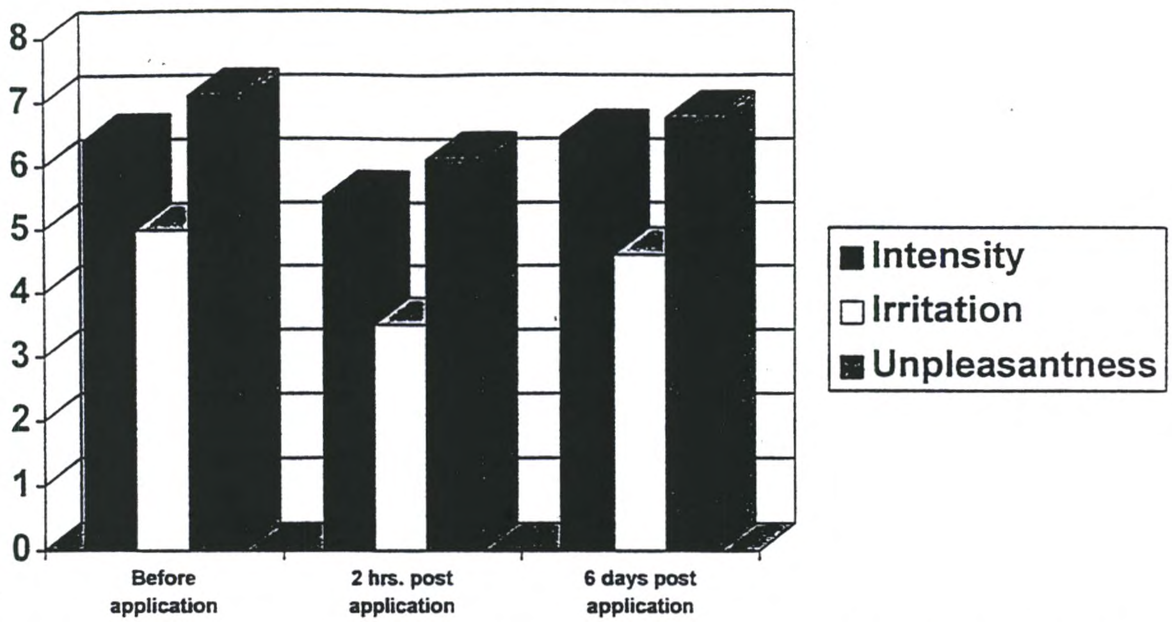

Figure 7. Odor perception results. Commercial-scale evaluation of o-dichlorobenzene, Site #1.

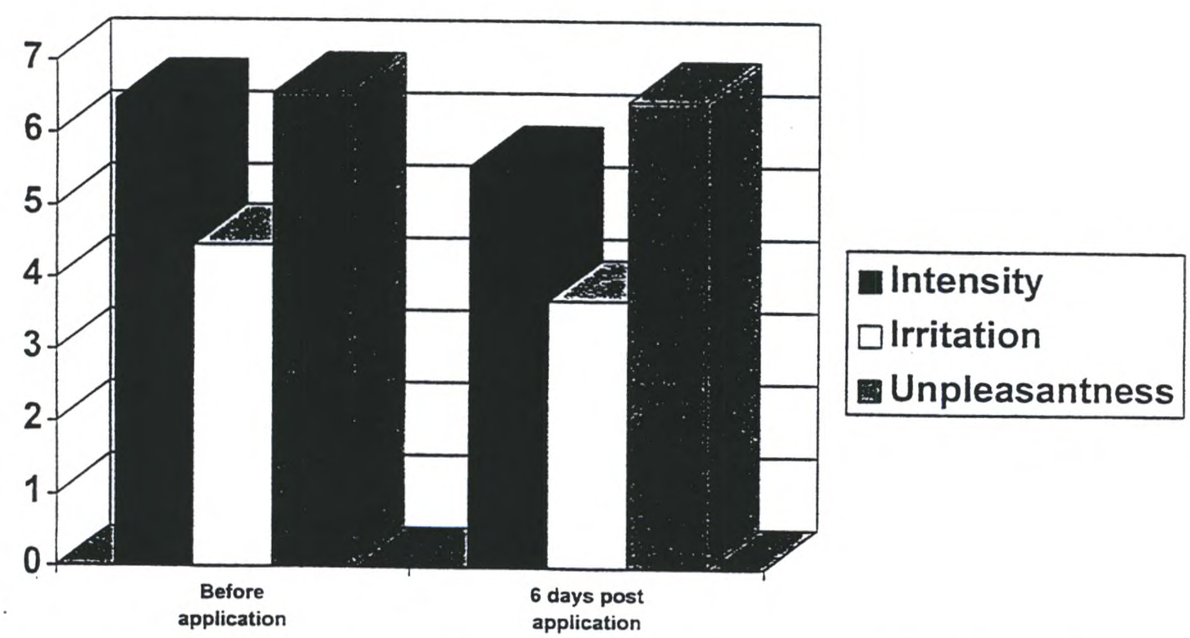

Figure 8. Odor perception results. Commercial-scale evaluation of o-dichlorobenzene, Site #2.

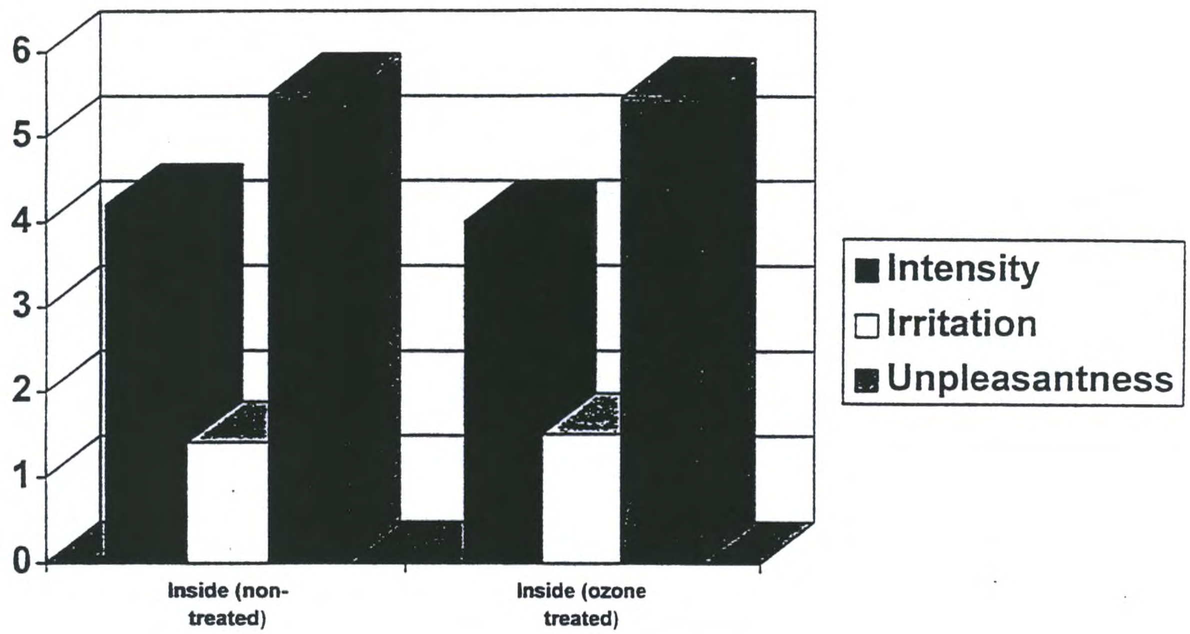

Figure 9. Odor perception results. Commercial-scale evaluation of ozone, samples collected from inside swine houses.

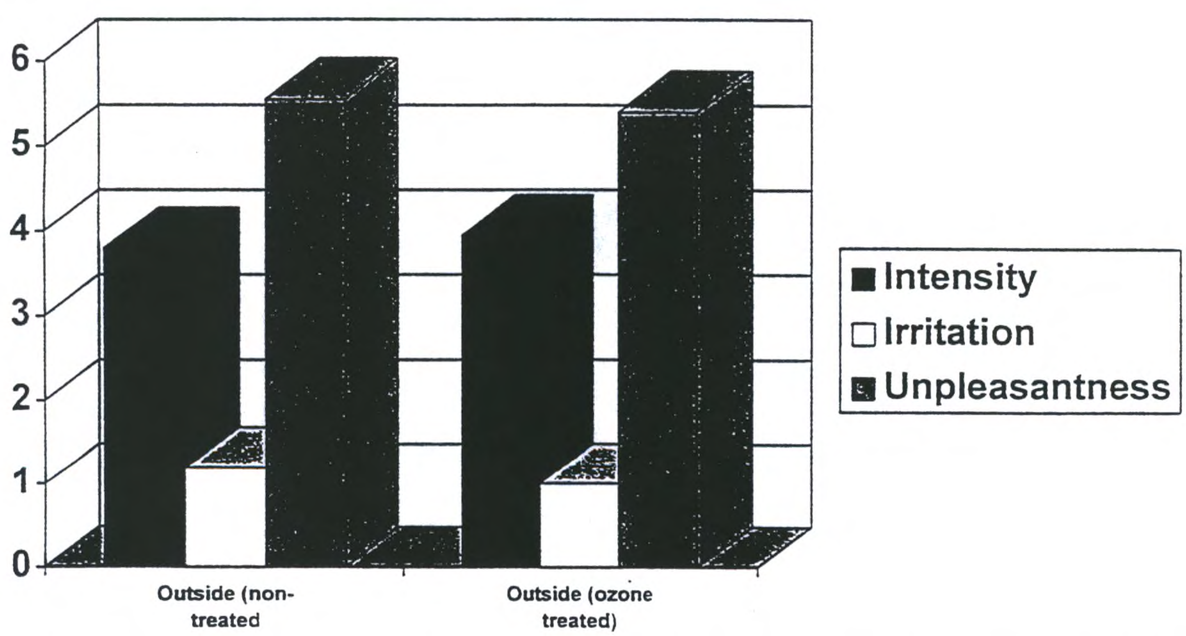

Figure 10. Odor perception results. Commercial-scale evaluation of ozone, samples collected from outside of swine houses at the exhaust fans.

ODOR ABATEMENT: PROGRESS AND CONCERNS

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ODOR FROM CONCENTRATED ANIMAL FEEDING OPERATIONS (CAFO'S)

Livestock and poultry operations sometimes produce unpleasnat odor that is an annoyance to and affects the well being of nearby residents. The degree of annoyance to odors depends on specific characteristics including odor intensity, frequency, duration, character (hedonic tone), and pleasantness or unpleasantness (offensiveness) (Dravnieks and O'Neill, 1979). Exposure to odor is sometimes regarded as "a serious threat to the sense of well-being: nausea, depression, headache, and even the belief itself that malodors are threatening health..." (NRC, 1979). Shiffman et al. (1995) reported that persons exposed to swine farm odors in a North Carolina study had more total mood disturbance (tension, anger, confusion, depression and fatigue) as compared to control participants.

Animal manure odor is composed of gaseous compounds that are intermediate and final products of biodegradation and includes these groups: ammonia and amines, sulfides, volatile fatty acids, alcohols, aldehydes, mercaptans, esters, and carbonyls (NRC, 1979; Miner, 1975; Barth et al., 1984; ASAE, 1987). Hall (1995) compiled a list of 121 different volatile compounds have been identified in gases emitted from swine manure together with threshold concentrations. Concentrations of these compounds at downwind locations are low, however, they may exceed human olfactory threshold values and create nuisance conditions.

Odor intensity or concentration and odor offensiveness can be measured quantitatively by human observers using appropriate methods (Watt et al., 1992). The technologies for odor measurement were described by Sweeten (1995) and McFarland and Sweeten (1995). Using these technologies, odors from livestock and poultry operations can be quantified through field studies; abatement methods can be developed and refined; and the effectiveness of control methods can be evaluated.

Dispersion modeling can also be attempted to predict the area affected by odors from livestock facilities (Carney and Dodd, 1989; Smith, 1993).

CONTROLLING ODOR: THE APPROACHES

With the magnitude of investments in new CAFO's and the sometimes exorbitant expense of legal actions involving odor nuisance, the needs are increasing to apply available odor measurement technology and to evaluate odor abatement methods. Specific methods have been divised to reduce odor from livestock facilities (Miner, 1974 and 1975; Barth et al., 1984; Sweeten, 1988 and 1992). The American Society of Agricultural Engineers has adapted an engineering standard for manure odor control (ASAE, 1987).

Avilable odor control methods generally fall into three broad categories (Sweeten, 1988):

1. Manure treatment - Methods include ration modification, aeration, aerobic digestion, anaerobic digestion or biochemical treatment. Some research points the potential of ration modification and/or manure treatment with chemicals or biochemical agents to reduce odor. For confinement buildings, frequent manure collecton through flushing, scraping or pit-recharge systems will reduce odors from ventilation fan exhaust. Likewise, solids separation and proper sizing of anaerobic lagoons to provide low volatile solids loading rates or, alternatively, lagoon aeration has been shown to reduce odor concentration. Essentially all these methods are consistent with positive contributions to protection of groundwater contamination and also reducing the emissions of methane (biogas) to the atmosphere.

2. Capture and treatment of odorous gases - The specific methods include using covered storage pits or lagoons (flexible membrane or floating biomat), soil incorporation, soil absorption beds or filter fields, or packed bed scrubbers (Sweeten et al., 1991; Kowalewsky, 1981; Licht and Miner, 1978; and Warner et al., 1990). These methods apply primarily to confinement buildings for swine or poultry or to composting systems. Soil injection of liquid manure, or alternatively disking liquid or solid manure into the soil after application, reduces odor emissions greatly, also (Lindvall, 1974).

3. Odor dispersion - This is accomplished mainly by selecting a site that is far enough away from neighbors and that takes advantage of topography, wind-direction frequency data, and atmospheric stability data. Modeling of odor dispersion to predict odor impacts more accureatly in advance, before

projects are actually built, is also a promising new field (Smith, 1993).

To provide a technical basis for regulatory approaches that are reasonable, enforceable, and practical, an understanding of odor generation processes, odor sampling and measurement techniques, odor control methods, dispersion phenomenon, predictive modeling, and odor impact (community responses) is needed.

ODOR MEASUREMENT TECHNOLOGY AND APPLICATIONS

People sometimes interpret odor to be a health risk indicator (Van harreveld, 1993). Agricultural odors such as from CAFO's can cause nausea, and headaches; produce breating difficulties; upset sleep; cause stomach upsets and loss of appetite; and irritate the eyes, nose, and throat (Watts, 1992). Unpleasant sensations associated with exposure to odorants (odorous substances) is sometimes regarded as "a serious threat to the sense of well-being: nausea, depression, headache, and even the belief itself that malodors are threatening health..." (NRC, 1979).

Odor characteristics that contribut to annoyance or odor nuisance conditions are: (a) intensity, concentration or strength of the odor; (b) odor frequency, or number of times detected during a time period; (c) duration of the period in which the odor remains detectable; (d) character (hedonic tone); and (e) perceived offensiveness (pleasantness or unpleasantness) of the odor (Dravnieks and O'Neill, 1979; Jones, 1992).

Odor intensity or concentration can be measured quantitatively by human observers using appropriate odor measurement technologies (Dravnieks and Prokop, 1975; Bulley and Phillips, 1980; Watts et al., 1990; Barth et al., 1984; and Watts, 1991). General approaches and methods used to measure the concentration or intensity of livestock manure odors include: (a) measurement of concentrations of specific odorants (directly or indirectly); and (b) sensory methods, which involve presenting odor samples (diluted or undiluted) to human panelists.

Odor offensiveness can be quantified also (Watts et al., 1992). Perceived offensiveness is a qualitative response of humans to both the character and intensity of an odor (Jones, 1992). Watts (1992) proposed that regulatory approaches for offensive odors should take into account both odor intensity and the cumulative hours of exposure per year (i.e. frequency times duration). Measured changes in both odor intensity and degree of offensiveness (quality) may be required for a complete evaluation of odor control systems (Bulley and Phillips, 1980).

Odor frequency and duration are partly dictated by climatic conditions, including wind-direction frequency, atmospheric stability, and moisture conditions. Dispersion modeling based on odor measurement can be used to predict the area affected by odors from livestock facilities (Carney and Dodd, 1989).

Electronic Sensors

Recent world-wide attention has been given to development of electronic volatile gas detection methods linked to remote, automated odor monitoring networks. Methods include: metal oxide semi-conductor capacitors; chemically modified field-effect transistors; optical divices; and piezo-electronic quartz crystal devices (Mackay-Sim, 1992). The mass of gas molecules added to the surface of piezo-electric crystals decreases the resonant frequency. Chemical specificity of the sensor surface can be altered to respond to single chemicals. Antibodies or receptor proteins from the human sensory cells attached to the crystal surface are being used in research instrumentation to imitate the human olfactory system.

A portable electronic odor level indicator that detects odor molecules using a high sensitivity metal oxide (SnO_2, ZnO) thermal semiconductor sensor has been used in feedlot odor research (Watts, 1992). Berchmans et al. (1992) developed a thick film semiconducting metal oxide sensor for monitoring ammonia concentations within, and emissions from, livestock confinement buildings.

Sensory Methods of Odor Measurement

Olfactometry using the numan sense of smell as the sensor is the most valid method for ambient odor measurement (Berglund et al., 1988). Sensory methods have been developed and receive widespread use (NRC, 1979). Approaches to sensory odor measurement include: (a) absorption media; (b) olfactometry, which involves presenting diluted odor samples to panelists; and (c) supra-threshold referencing in which the panelists compare the intensity of the undiluted odor to a known concentration of a reference compound. Sensory methods based on these approaches include:

1. Absorption media-cotton fabric swatches
2. Supra-threshold referencing methods-butanol olfactometer
3. Dilution-to-threshold (olfactometric) methods
   a) Syringe dilution method (ASTM, 1978)
   b) Scentometer (Barnebey-Cheney, 1973)
   c) Dynamic forced-choice olfactometer (Dravnieks and Propkop, 1975; Jones 1991 and 1992; ASTM, 1991)

Testing methods generally involve five basic steps (Bulley and Phillips, 1980): (a) sample collection; (b) sample dilution and presentation to panelists; (c) indication of response; (d) response interpretation; and (e) presentation of results. Detailed procedures for each step must be specified and followed for proper interpretation of results.

Types of Odor Thresholds: In making diltuion to threshold measurements, the panelist responds to the detection (awareness) threshold, where the presence of an odor is sensed (Bulley and Phillips, 1980) rather than the recognition threshold (where the odor is both sensed and recognized). the sample concentration at the recognition threshold is 1.5 to 10 times higher than at the detection threshold (Dravnieks and Jarke, 1980). Presentation of odor samples in ascending concentrations will minimize the effects of odor fatigue, and each dilution should be followed by a 1 minute recovery time (Bulley and Phillips, 1980). The dilution level at which half the panelists detect the odor and half do not is regarded as the threshold value (Astle and Duffee, 1981). Odor threshold is not a constant value but is the approximate volumetric concentration where greatest disagreement is registered by the panelists' responses. Considerable disagreement has been reported among various research reports as to threshold concentrationfor odorants (Amoore, 1985). The value of odor threshold depends to a great extent on the methods involved (Dravnieks and Jarke, 1980), and a concentration range is more appropriate than a single value (ASTM, 1991).

Dynamic Olfactometers: Dynamic olfactometers have several advantages over other dilution-to-threshold methods including reproductibility and statistical reliability (Dravnieks and Jarke, 1980). Several types of dynamic olfactometers have been developed worldwide and there is no universally accepted instrument. The odor threshold for the panel is determined in various ways (Jones et al., 1993): (a) geometric mean of the individual panelists' thresholds; (b) highest dilution level at which half the panelists correctly detect the odor of the diluted sample and half do not; or (c) graphically, by plotting the percent correct responses versus dilutions to threshold (odor units) and interpolating between the dilutions actually tested to determine the 50% correct response level (ED_{50} value). A correction factor may be applied to the results to account for the probability of a correct panelist response due to guessing (Smith et al., 1992).

Dynamic olfactometry has become the most widely accepted means of odor measurement in most parts of the world including Europe, Australia and the U.S. Commercially available dynamic olfactometers differ significantly in design and yield different threshold values (Dravnieks and Jarke, 1980). A U.S. standard for use of dynamic forced-choice triange olfactometers has been drafted (ASTM, 1991; O'Brien, 1993). European countries use one of the several different types of dynamic olfactometers to evalue odor offensiveness and intensity, and there are differences in the guidelines followed (Jones, 1991). The Dutch Pre-Standard for dynamic olfactometry (two-port type) is designed to improve reproductibility and accuracy (DNI, 1990) and is being proposed as the basis of an European Standard (Van Harreveld, 1993; Watts et al., 1993). Sweeten and Rodriquez-Akabani (1994) compared design features and methods for dynamic forced-choice triangle olfactometers used in the U.S., Europe, and Australia.

Jones et al. (1993) compared 1-butanol thresholds for odor panels using 23 different European, U.S. and Australian dynamic forced-choice olfactometers of at least 7 different designs. Standardization of equipment and procedures and rigorous panel selection have resutled in lowering the reference 1-butanol threshold. It is necessary to establish butanol threshold vlaues for each dynamic olfactometer, for each panel, and for each day of testing; and the butanol threshold of the olfactometer/panel combination needs to be quoted along with the results of odor concentration.

SUMMARY AND CONCLUSIONS

Odor measurement science and technology is being applied worldwide to the design, development and evaluation of odor abatement practices. Odor measurement can lend a scientific basis to odor regulation including site selection, complaint resolution, and nuisance litigation. Three basic appraoches to odor measurement are: a) odorant monitoring (i.e. instrumental measurement of specific known odorous gases); b) sensory measurement (i.w. using human odor panelists); and c) electronic odor sensing. Instruments use semiconductors and thin-film technology. Sensory odor measurement methods include olfactometers, which allow quantification of odor strength by human panelists in terms of perceived odor intensity or concentration. Olfactometers most commonly used for measuring odor from concentrated animal feeding operations include the Scentometer, several types of dynamic olfactometers, and 1-butanol olfactometers. In some cases, regulatory standards have been developed for odor concentration based on olfactometer measurements.

The dynamic forced-choice olfactometer approach to odor measurement using panels of 8 or more people is gaining acceptance. Efforts to standarize odor measurement equipment in Europe, Australia, and the United States include specifications on hardware/instrumentation, procedures, panelist selection, and data reductin/analysis techniques.

Research in the U.S. on livestock and poultry manure odor using dynamic forced-choice triangle olfactometers is lacking, notwithstanding research in Australia and Europe with this instrumentation.

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ODOR ABATEMENT: PSYCHOLOGICAL ASPECTS OF ODOR PROBLEMS

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The sense of smell, or olfaction, is the least understood of the five senses. This is due, in part, to the individual subjectivity of the sense. Subjectivity encompasses both variation in sensitivity among individuals as well as personal preferences based on psychological influences. Difficulties arise when studying olfaction in lower animals. While use of lower animals is easier from a mechanistic approach, the sense of smell is much more developed in lower animals than in humans thereby making comparisons to humans inappropriate.

An understanding of 1) chemical basis of odors derived from animal manures, 2) variation in detection thresholds among people and odorous compounds, and 3) differences in the degree of offensiveness that people assign to different odors depending on their background and experience is helpful to animal-food producers to design manure management systems and public relations strategies which avoid nuisance complaints.

ODOROUS CHEMICALS IN MANURES

Biochemistry

Over 75 odorous compounds, in varying proportions, have been identified in livestock manures. The number is much greater if all intermediary degradation forms of primary chemicals are counted. The biochemical derivation of odorous compounds and the physical chemical principles affecting release of volatile compounds was described succinctly by Merkel et al. in 1969 and is the basis of the description which follows.

Groups of primary odorous compounds identified include, volatile organic acids, aldehydes, ketones, amines, sulfides, thiols, indoles and phenols. All of these groups can result from the partial decomposition of manure. The breakdown is accomplished by a mixed population of anaerobic bacteria, commonly grouped into either acid-forming or methane-producing classes. The acid formers are responsible for the initial breakdown of complex molecules into short-chain compounds, including organic acids. The methane bacteria further reduce the organic acids to methane and carbon dioxide if conditions permit action by methane producers.

The breakdown of proteins proceeds to ever-simpler proteoses, peptones, peptides, amino acids and, finally, to ammonia and volatile organic acids such as formic, acetic, propionic, and butyric acid. Due to the presence of sulfur in certain amino acids (sulfur averages about 1% of most proteins), various sulfides and mercaptans can be expected as a result of protein catabolism.

Carbohydrates in animal wastes include sugars, starch, and cellulose. Starch and cellulose are broken into glucose (sugar) units as the first step of degradation. Under anaerobic conditions, sugars are degraded to alcohols, aldehydes, ketone, and organic acids. These intermediates, which are odorous, can be further metabolized and transformed to methane, carbon dioxide, and water (nonodorous end products) if conditions permit methane-producing microorganisms to function.

Fats are esters of the trihydroxy alcohol, glycerol. Bacteria use fats as an energy source, hydrolyzing them first to the corresponding long-chain fatty acids and alcohols. These acids, along with those produced in the deamination of amino acids, undergo further breakdown in which acetic acid is cleaved from the original acid. Acetic acid is then potentially utilized as an energy source, yielding methane and carbon dioxide as end-products.

From an examination of the metabolic pathways for the breakdown of manure constituents, organic acids, alcohols, aldehydes, sulfides, and simple hydrocarbons as well as carbon dioxide, ammonia, and methane are expected. The presence of this mixture of organic materials and ammonia in an aqueous solution leads to the formation of several other groups as reaction products. For example, ammonia in water, being a H^+ receptor, may be expected to react with acids and alcohols to yield amides and amines. Also, hydrogen sulfide in water may combine with alcohols, aldehydes, and acids to form mercaptans, thiols, and thioacids.

An accumulation of these intermediate metabolites results in an offensive smelling product whereas containment of the intermediate compounds for sufficient time to permit methane producers to act completely permits metabolism of the most of the odorous compounds to nonodorous methane. Background levels of sulfur in water may also be a source of odor.

Physical Chemistry

Biochemistry is useful in predicting the classes of compounds that one might find in a manure storage pit or lagoon where anaerobic decomposition is taking place. Physical chemistry is useful in predicting those compounds most likely to be prevalent in the atmosphere above such a solution. For a material to be present in the atmosphere, it must escape the liquid phase. Thus, vapor pressure is an important factor. Within specific types of compounds, vapor pressure generally decreases with increasing molecular weight. The smaller members of any series should be more important with respect to atmospheric composition.

The solubility of a compound in water is another important factor in evaluating its significance as an atmospheric contaminant. Insoluble gases, such as methane, escape immediately after being produced, whereas more soluble compounds, such as ammonia, are retained in solution and can be involved in biological and chemical reactions. Solubility of many compounds, and hence odor, is markedly influenced by the solution's pH. Hydrogen sulfide is a particularly good example of pH effect. Under conditions of high pH, almost no odor is detected, while under acid conditions, the H^+ and HS^- ions combine, escape, and produce the typical sulfide odor (H_2S). Ammonia is another good example of pH effect. The NH_3 in an acid medium accepts H^+ to produce NH_4^+ which stays in solution and does not volatilize. Even with pH up to 8, ammonia remains relatively soluble in liquids and little ammonia odor is detected.

No single compounds have been found to be good predictors of odor sensation across varied situations in the field. Hence, odor sensation is most often measured organoleptically by panelists to quantify intensity and unpleasantness.

PHYSIOLOGICAL VARIATION AMONG INDIVIDUALS

An odor's detection threshold identifies the concentration at which 50% of a human panel can identify the presence of the odor or odorant without characterizing the stimulus. Although the threshold concentrations of substances that evoke a smell are slight, e.g. Table 1, a concentration only 10 to 50 times above the detection threshold value often is maximum intensity that can be detected in humans. This is in contrast to other sensory systems where maximum intensities are many more multiples of threshold intensities, e.g., the maximum intensity of sight is about 500,000 times that of the threshold intensity and a factor of 1 trillion is observed for hearing (Guyton, 1986). For this reason, smell is often concerned with identifying the presence or absence of odor rather than with quantifying intensity or concentration.

The ability to perceive an odor varies widely among individuals. More than a thousandfold difference between the least and most sensitive individual subjects in an acuity has been observed (Harper et al., 1968). Differences between individuals are in part attributable to age of the individual, smoking habits, and presence of nasal allergies, or head colds. Generally, the olfactory sensory nerves atrophy from the time of birth to the extent that only 82% of the acuity at birth remains at the age of 20, 38% at the age of 60 and 28% at the age of 80 (Water Environment Federation, 1978). Olfactory acuity and like or dislike of an odor decrease with age (Schiffman and Gatlin, 1993). Infants appear to like all classes of odorous materials, perhaps related to lack of previous experience combined with innate curiosity. Children under five rated sweat and feces as pleasant but above five years of age, as unpleasant (Gorman, 1964). At this age, however, cultural perceptions of particular odors may begin to exert greater influence over a child than in previous years and a biological explanation for this change in acceptability is not evident. Like and dislike of a particular odor can also change with odor concentration or intensity (Cheremisinoff and Young, 1975). Nonsmokers over the age of 15 show greater acuity than smokers of all ages (Cheremisinoff and Young, 1975).

Generally, man can distinguish between more than 5,000 odors but some individuals experience smell blindness for one or more odors, i.e., while they apparently have a normal sense of smell they are unable to detect one particular odor regardless of the intensity. For example, because methyl mercaptan has an odor recognition threshold of only 0.0021 ppm (Table 1), it is often mixed with natural gas as an indicator of leaks (Water Environment Federation, 1978); however, approximately one in one thousand persons is unable to detect the strong odor of this mercaptan (Harper et al., 1968). In the elderly population, an estimated 30% have lost the ability to perceive the minute amount of this mercaptan used in natural gas.

Adaptation is the process by which one becomes accustomed to an odor. When more than one odor is present, the adaptation time needed is greater. When adaptation occurs, the detection threshold increases. It can be shown that the detection threshold limit changes faster when an odor of high intensity is presented than when one of low intensity is presented and, also, that adaptation is different for different odors (Cheremisinoff and Young, 1975). Odor fatigue occurs when total adaptation to a particular odor has occurred due to prolonged exposure. This situation would apply, for example, to milkers or dairy managers who are exposed to the smell of dairy manure on a daily basis and appear virtually unaware of the odor on the work site.

TABLE 1. Examples of varying threshold measurements of odorous substances (odorants)[a]

Odorant	Characteristic odor	Odor threshold (ppm)	Detection threshold (ppm)	Recognition threshold (ppm)
Acetaldehyde	Pungent fruity	.004	–	.21
Allyl mercaptan	Strong garlic, coffee	.00005	.016	–
Ammonia	Sharp pungent	.037	–	46.8
Amyl mercaptan	Unpleasant, putrid	.0003	–	–
Benzyl mercaptan	Unpleasant, strong	.00019	–	–
Butylamine	Sour, ammonia-like	–	–	.24
Cadaverine	Putrid, decaying flesh	–	–	–
Chlorine	Pungent, suffocating	.01	.01	.314
Chlorophenol	Medicinal, phenolic	.00018	–	–
Crotyl mercaptan	Skunk-like	.000029	.0077	–
Dibutylamine	Fishy	.016	–	–
Diisopropylamine	Fishy	.0035	–	.085
Dimethylamine	Putrid, fishy	.047	–	.047
Dimethylsulfide	Decayed vegetables	.001	–	.001
Diphenyl sulfide	Unpleasant	.000048	–	.0021
Ethylamine	Ammoniacal	.83	–	.83
Ethyl mercaptan	Decayed cabbage	.00019	.0026	.001
Hydrogen sulfide	Rotten eggs	.00047	–	.0047
Indole	Fecal, nauseating	–	–	–
Methylamine	Putrid, fishy	.021	–	.021
Methyl mercaptan	Decayed cabbage	.0011	–	.0021
Ozone	Irritating above 2 ppm	.001	.5	–
Propyl mercaptan	Unpleasant	.000075	.024	–
Putrescine	Putrid, nauseating	–	–	–
Pyridine	Disagreeable, irritating	.0037	–	–
Skatole	Fecal, nauseating	.0012	.223	.47
Sulfur dioxide	Pungent, irritating	.009	–	–
Tert-butyl mercaptan	Skunk, unpleasant	.00008	–	–
Thiocresol	Skunk, rancid	.0001	.019	–
Thiophenol	Putrid, garlic-like	.000062	.014	.28
Triethylamine	Ammoniacal, fishy	.08	–	–

[a]From Water Environment Federation (1978). Although odor threshold was not defined in this table, it is assumed that odor threshold = dose eliciting a response 50% of the time by animals (National Safety News 116:(Sept., 1976). Deciton threshold = dose at which 50% of human panel can detect odor, recognition threshold = dose at which 50% of human panel can identify which odor it is.

Both ammonia and hydrogen sulfide can cause olfactory losses as a result of chronic or prolonged exposure. Ammonia can affect the central nervous system (ASTM, 1968). A number of other chemical pollutants also result in losses in olfaction by damaging olfactory receptors. Some insecticides are included in this category. Knowledge of the exact mechanisms by which pollutants alter olfaction is limited. Effects on individuals vary from one person to another. Also, the use of medications may exacerbate chemosensory disorders. However, it is known that olfactory receptors renew themselves every thirty days, on average. Pollutants may alter this turnover rate or disrupt the integrity of the lipid membranes of olfactory receptors (Schiffman and Nagle, 1992). Threshold levels have been identified for a number of pollutants above which odor or irritation occur.

Ammonia, hydrogen sulfide and organic acids produce odors commonly associated with livestock operations. For the above mentioned reasons, as well as neighbor complaints, reduction of these compounds in manure is desirable. As perceived by humans, odors have five basic properties that can be quantified: 1) intensity, 2) degree of offensiveness, 3) character, 4) frequency, and 5) duration, all of which contribute to the attitude of the neighbor towards the odor as well as towards the business generating it (Sweeten, 1988). It is generally accepted that the extent of objection and reaction to odor by neighbors is highly variable. The reaction can be based on previous experience, relationship to the odor-producing enterprise and the sensitivity of the individual (Miner, 1977). Frequency and duration are weather-related. Weather (temperature, humidity, wind direction) affects the volatility of compounds, preventing or enhancing movement into the gaseous phase where an odor can be dispersed downwind.

PSYCHOLOGICAL INFLUENCE OF ODOR PERCEPTIONS

Detectable odors can have a significant impact on people by affecting moods as well as having physiological effects on the olfactory system. Odors have been implicated in depression and nausea as well (Miner, 1980). People associate odors with past experiences and, from those experiences, spontaneously and involuntarily assess the odor as likable, dislikable or indifferent. Much of an individual's perception of an odor may stem from their association of that odor with a secondary factor although the extent to which emotion influences odor perception is difficult to assess. Persons living near large-scale hog operations reported greater stress, tension, depression, anger, fatigue and confusion than control subjects in a study conducted by Schiffman (1995) however, participant attitudes toward hog operations, in general, and their neighboring operator, in particular, were not considered in this study.

Other surveys have correlated resident profiles with odor annoyance (Lohr, 1995). Residents within a half mile radius of two southern Michigan swine operations were asked to comment on the degree to which odor impacted their property enjoyment. Residents also responded to an extensive questionnaire which explored such areas as the amount of time they had resided in the area, how much time was spent at home, their occupation, how they characterized the area, extent of interaction with the swine operators, knowledge and opinion of the swine operations, and frequency and timing of odor problems. The results indicated that odor was perceived to be worst in the summer which may be due in part to residents spending more time out of doors during the summer months. Length of residence, economic dependence on farming, and contact with the farmers were all negatively correlated with odor annoyance. The correlation suggests that odors are better accepted by individuals who see the operator as a community member, friend, neighbor, or employer. Biological adaptation to odors may play a role in the responses of long time residents or those who work in agricultural fields as well. A positive correlation was found between odor and visual appearance of the swine operation demonstrating the psychological impact that visual assessment has on odor perceptions.

To demonstrate the impact of suggestion on one's psyche Knasko (1990) asked subjects to evaluate the effect that a perceived odor had on their performance of simple tasks (clerical coding, digit deletion). Prior to starting the tasks subjects were told that the room would be intermittently scented with a pleasant (or unpleasant or neutral) smelling substance. In all cases the scent was that of water. However, subjects who were told that the scent would be unpleasant reported that the scent had a negative influence on their performance and their emotional and physical states. No differences in task performance between the three groups was found. Subjects seemed predisposed to report physical symptoms when they were given a suggestion of malodor even when none existed emphasizing the power of suggestion.

In a second study participants were asked to perform simple tasks while the room was intermittently sprayed with pleasant (lemon and ylang), unpleasant (isovaleric acid and skatole) or control (unscented) scent and then questioned about how they thought the odor affected their mood, health, and performance (Knasko, 1993). Subjects who had been exposed to the malodor reported negative effects on mood, health, and task performance although measured effects were not significant.

CONCLUSIONS

Odor nuisance complaints regarding agricultural operations stem from a physiological basis which varies from one individual to another based on individual sensitivity.

However, those dealing with such complaints must be aware of the potential for psychological bias towards livestock operations which may trigger belief that odors can cause or exacerbate health symptoms. Such bias may also lead one to believe that odors and symptoms are experienced when one or the other may not have existed.

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IMPORTANCE OF USING CURRENT ECONOMIC INFORMATION TO DEVELOP ENVIRONMENTAL PROGRAMS

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Environmental aspects play an important role in management decisions taken by poultry farmers in the Netherlands. An overview of the regulation is given in the paper "Company involvement in emerging environmental issues: International perspective". To solve the problem of a surplus of minerals there are three solutions: modifying the feed, improving manure distribution and manure processing. In order to reduce the ammonia emission modification of housing systems have to be implemented.

MODIFYING FEED

As the Dutch governmental regulation are based on phosphorus, in research a lot of attention is given to this mineral. Feed composition and dietary regimes can be more closely adapted to the nutritional requirements to avoid overfeeding and excretion of undigested components. The use of the enzyme phytase can help improve digestibility.

In the Netherlands the manure production rights (in kilogram phosphorus) for poultry was subject to a once-only reduction of 30% in relation to the reference quantities for 1986. As a result, poultry farmers now use poultry feed with the enzyme phytase in order to reduce the amount of phosphorus in the manure. The economic impact of using phytase is a function of several factors including the cost of the phytase product, the degree of replacement of mono-calcium phosphate (MCP) and the quantity of animal by-product meal in the ration (Barr, 1996). Feedmills in the Netherlands report that the feed costs didn't increase after modifying the feed. The additional costs of the enzyme phytase are compensated by the savings of leaving out the additional MCP. Extensive research in the Netherlands has shown that production results aren't affected in diets with phytase (Van der Klis, 1995).

MANURE DISTRIBUTION

Poultry and pig production is concentrated on the sandy soil region of the Netherlands. From this area manure can be distributed to other regions where the main agricultural activity is arable farming or dairy. The distribution distance within the country is 100 to 200 kilometer. In order to reduce the transport volume of the manure, the layer farms are rapidly changing to manure drying housing systems. At the moment more than 50% of the layers are kept in cages with manure belt drying systems. Through activities of the manure bank there was a large increase in distribution of manure within the country. The consequence is an increase in manure disposal costs for the poultry farmer. An example: the costs for a broiler farmer increased from a revenue of 15 Netherlands Gilder (NLG) in 1985 to a disposal cost of 15 NLG per ton broiler manure. The manure bank is also supporting the export of dried poultry manure. The minimum dry matter percentage of manure is 55. At the moment, a considerable part of the dried poultry manure is exported to neighboring countries like Germany, Belgium and France. Especially on the arable farms in the Northern part of France (400 to 500 kilometer from the Netherlands) there is a shortage of manure. In fact, the export of manure is bringing back the minerals to the grain production areas. The target of the government is to export all the (dry) poultry manure in order to apply the low quality (low dry matter percentage) pig slurry in the Netherlands.

MANURE PROCESSING

In various countries, but especially in The Netherlands, systems are being developed for the industry processing of pig and poultry manure. The final product is dried fertilizer. Great effort has been made in the development of processes to convert pig slurry into fertilizer and feed ingredients. The first plant, built by Promest, was increased to a capacity of 600,000 meter^3 per year. The processing costs have been a major source of concern. Very strict emission standards in the Netherlands are a major cause of the high costs (ten Have, 1993). Although the Dutch government and agribusiness supported the industrial manure processing, this plant was closed in 1995. Besides the high costs of processing, the lack of confidence from farmers and a lack of willingness to guarantee a long term manure supply was the main bottle neck.

Because of the same reason two factories processing dry poultry manure into manure pellets closed in 1995.

In England, there are two factories burning broiler manure. There is serious interest from Italy to build similar facilities. Compared to the situation in the Netherlands support from electricity companies and lower standards for air pollution are the reason for the success in the UK.

LOW AMMONIA EMISSION HOUSING SYSTEMS

In order to reduce the ammonia emission in the Netherlands great efforts are made to develop new housing systems with a low ammonia emission. For layers, a clear review is given by Groot Koerkamp (1994). In the Netherlands more than half of the layers are kept in cages with a manure belt and an air drying system. The manure is dried constantly and ammonia emission is low. This system has an official 'green label'. In case of replacement of old cages, the manure drying system is economical for the farmer compared to a wet manure system. The higher investment in energy costs for drying are compensated by lower manure disposal costs, lower governmental levies and saving on investments in manure storage facilities. A new development is further drying of the manure at farm level towards 70 to 80% dry matter. In the current situation these systems are still to expensive, but some of them give perspective. To be mentioned are the controlled composting of manure and manure storage drying with a ventilated floor. Keeping birds on litter, such as broilers, turkeys and breeders, makes it more complicated to reduce the ammonia emission. A new housing system is the ventilated litter floor. Although reduction of the ammonia emission was the original aim, the system seemed to have an effect on growth results as well (van Middelkoop, 1995). due to regional regulations, four farms in the Netherlands installed a ventilated floor on there farm. Economic calculations show that the additional costs for investment can only be compensated partly through the better performance of the broilers. In contrast it seems that a partially ventilated floor for turkeys can be economical (van Horne, 1995).

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MANIPULATION OF ENVIRONMENTAL LAWS TO SUPPRESS COMMERCIAL ANIMAL PRODUCTION

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Current public perception seems to place livestock producers as a blight on society that is out of control. With that in mind, this is an economist's view of how commercial livestock producers have lost control of their right to raise livestock.

Changes in the agriculture industry have brought a number of unintended and unforseen consequences. Commercial livestock facilities have grown in size and concentration, and so has the size of their waste streams. This creates some legitimate and perceived fears about livestock facilities. The principle social concerns revolve around nutrients, pathogens (cryptosporidium) and odors. The current challenge is trying to quantify these environmental liabilities in such a way that fact and fear can be separated.

There is an additional story to tell. This new story, or paradigm, sets environmental standards on the items of concern (outcomes) rather than on livestock (inputs). With the proper incentives in place these liabilities will not occur. Rather than building a regulatory infrastructure to control environmental concerns, the concerns disappear. This is the story of how livestock producers can, and will, reclaim their right to raise livestock. This new strategy moves animal agriculture out from under an environmental attack into a revenue-driven, socially-acceptable commercial animal production paradigm.

THE PARADIGM LOST

It is no longer business-as-usual for the commercial livestock industry. The animals are still highly regarded by the public. It is the livestock producers that have come under scrutiny.

Livestock producers have been caught up in the social demand for assurance of a clean environment. This has manifest itself in the evolution of federal environmental legislation to facilitate federal oversight of the nation. Federal environmental legislation has become the indicator of the social demand for the environment.

The publicly driven demand for a clean environment has forced the government to take responsibility over a domain which it still does not understand. There is still much work to do to split the facts from a perceived fear of commercial livestock production.

This paper focuses on the federal environmental statues, which are described by Copeland (1995a) as the Clean Water Act, Coastal Zone Management Act, Safe Drinking Water Act, Clean Air Act, Comprehensive Environmental Response, Compensation and Liability Act, and the Federal Insecticide, Fungicide and Rodenticide Act. This discussion is primarily focused on the Clean Water Act, but from a policy standpoint, the implications could be extended to other statutes at both the federal and state levels.

The statutory focus on the environment has focused public scrutiny of the commercial livestock sector making livestock an easy target for environmental watchdogs. As a result, there has been a subtle, but significant shift in our legal structure and the organizational structure of agriculture has changed.

Livestock Producers are Easy Targets

The health of the environment is important for everyone. It is the implementation of environmental policy, or incentives, that is contentious. It is easier to find problems, than to find solutions. Policy decisions, good and bad, influence a livestock producer's ability to operate their business. The naive solution to cleaning up the environment appears too often to be to stop producing livestock. This was not a viable alternative to the 450 livestock farmers in the New York City Watershed (Coombe, 1996). In an effort to improve water quality, livestock and dairy producers would have essentially lost the ability to produce under the initial draft regulations. The aggressive action of a handful of the watershed's producers resulted in a science-based, cooperative agreement with New York City which allows them to remain in production.

In the 1970's the federal administration took authority as the federal environmental enforcer. This was a direct result of the environmental statutes such as the Clean Water and Clean Air Act. The formation of the Environmental Protection Agency

(EPA) as the federal environmental enforcer automatically implicates any challengers to EPA as degraders of the environment.

Livestock producers are also easy targets because agriculture just has fewer friends. An indirect effect of the structural change in agriculture is that agriculture has fewer voices. Nineteen percent of the agricultural industry is producing seventy-seven percent of the total products (Drury and Tweeten, 1995).

The Shift to Statute Law

Statute law removes the responsibility of socially correct behavior from individuals and places the authority for maintaining socially correct behavior with the authorizing administration such as the federal and state governments. This is contrasted to common law which is established on decisions made by judges on a case-by-case basis. With the establishment of the Clean Water Act in 1972, the federal government took authority for maintaining the quality of the waters of the United States (Yandle, 1996).

The actual environmental outcome of this shift is questionable. For all the dozens of environmental statutes passed by Congress, thousands of regulations written and hundreds of billions of dollars have been spent, little direct effort has been made to protect the environment (Meiners and Yandle, 1993). The focus is on inputs (livestock) not environmental outcomes (nutrients and pathogens). Furthermore, no one seems to be keeping score. Environmental outcomes appear to be more of a by-product of this gigantic process than the goal itself. More than 20 years later, we still lack the science and the government resources to regulate, monitor and enforce a top-down law such as the Clean Water Act.

Other pitfalls of the Clean Water Act are that it is implemented on approved practices, based on a zero-discharge effluent goal, and it facilitates criminalization of environmental neglect. By assigning approved practices, there is no incentive for innovation. Approved practices, indicate that they are tested and proven. In addition to the loss of innovation and the loss of use during the time in development, approved practices which focus on a single objective, such as nutrient mitigation, can preclude the ability to address other goals, such as odor control (i.e. anaerobic lagoons).

Regulations that have been developed tend to penalize livestock producers. They are based on animal units. To compound the matter further, the 1,000 lb animal unit evolved from steers (Brodie, 1993). In a convoluted way, all other classes of livestock are based on some proportion of a steer's production of manure. Broiler and layer chickens permitting standards reflect technologies that are not necessarily used anymore (Reynnells, 1993). National Pollutant Discharge Elimination System (NPDES) permits for Concentrated Animal Feeding Operations (CAFO) effluent discharge guidelines are based on the concept of zero discharge.

One of the most onerous pitfalls of the shift to statute law is the criminalization of environmental degradation. Copeland (1995b) provides an excellent review of the controversy regarding the criminalization of environmental law. Copeland (1995b) establishes the merit of prosecuting the bad-actors, those which degrade the environment with criminal intent. These cases were also captured under common law. The down side of criminal prosecution for environmental law violation include numerous cases where a government agency pursued prosecution of nominal violators. Some of the highly publicized cases resulted in the prosecution of documented environmentally-concerned individuals. Other cases were to punish publicly outspoken individuals. There is evidence that the threat of prosecution is used to force the accused into embarking on agency approved projects, a form of extortion.

The environmental statutes allow the federal government not only to prosecute the criminals, but also many producers without willful intent to do harm. The federal government does not have the science to enforce and monitor the laws that it has initiated.

The Change in the Structure of Agriculture

Another significant factor in livestock producers losing control is that the structure of agriculture is changing. Livestock facilities continue to increase in size and decrease in number (Drury and Tweeten, 1995). This is the result of many factors, but industrialization is allowing more food to be produced at lower costs to consumers.

The costs of regulation and compliance with environmental laws are part of the costs that the agriculture industry is seeking to reduce. With the zero discharge goal imbedded in the Clean Water Act, the two most obvious choices a livestock operation can make are to stop producing livestock (zero animal units) or get large enough to distribute the cost of regulatory compliance across more production units. The more units produced, the lower the cost-per-unit.

CONTROLLING ENVIRONMENTAL QUALITY THROUGH MARKETS

Shifting the responsibility of environmental oversight to the government through the use of environment statutes has not been effective. Commercial livestock producers are held responsible, but it is the current environmental policy that is failing -- not the livestock producers. An alternative to trying to make this complex, forced system work, is to shift to use of markets to ensure environmental quality.

The environmental statutes represent social environmental demand. Demand, however is an economic term. It seems a feasible consideration to examine the representation of the social environmental demand in terms of markets, as opposed to statutes. This would mean creating an economic demand for environmentally friendly products.

This can be done by developing markets for the environmental liabilities through reliance on common law (McEowen, 1996), reduced land values and tolerance payments near livestock facilities (Harl, 1995) or through nutrient permit trading (Riggs, 1994). These are all feasible alternatives, but they all manage manure and manure products as liabilities. As manure is managed as a resource, the nutrient and energy components in manure are reused. The liabilities disappear. For this to happen three things must occur: produce useful manure products, build output standards and know the market demand for manure products.

Produce Good Manure Products

All animals produce manure, but the kinds of environmental problems that arise on most farms can be traced to manure products rather than manure itself. Manure is fresh fecal material. Manure products result from manure storage and treatment systems. Odors are manure products. Anaerobic lagoons digest and transform the manure into methane, carbon dioxide and water. Broiler litter is a mixture of manure and the animal bedding. Manures that are composted are also processed forms of manure.

The current manure products generated are the result of efficient treatment systems that have been designed to minimize the cost of managing these products. The treatment system design objective has been to reduce environmental impact with the least-cost. This is the goal imposed by the environmental statutes. The best economic outcome possible from this design is zero costs.

However, if the design objective is to maximize the reuse of the nutrients and energy in manure, the resulting products are products of value -- not liabilities. Intensive management and an awareness of the demand for manure products will result in a corresponding revenue for producers. The resulting focus on re-use and recycling of manure products, removes manure and most of the livestock issues from the environmental domain.

Build Output Standards

With regulatory standards based on inputs -- rather than outputs, there are no incentives to conserve. It is not the number of animal units that are the environmental threat, but the manure products generated during the treatment process. A policy target on the social nutrient concerns would allow innovative producers to reduce nutrients. Table 1 illustrates the nutrient composition of broiler chicken manure and manure products. The lines which represent one and two cleanouts per year show that change in the management practice, as opposed to the treatment structure, can change the nutrient composition of the manure products.

TABLE 1. Broiler litter nutrient composition by product (annual lbs of nutrient/house).

	Annual N	P_2O_5	K_2O
Raw broiler manure[a]	48.4	34.1	18.2
Litter, 2 cleanouts/year[b]	45.0	84.9	42.0
Litter, 1 cleanout/year[b]	60.9	80.0	36.0
Composted broiler litter[c]	34.0	NA	NA

[a] Livestock Waste Facilites Handbook. 1993. MWPS-18.
[b] Jenner, Prato and Xu, 1994.
[c] On-Farm Composting Handbook. 1992. NRAES-54.

The numbers in Table 1 illustrate that the same class of livestock will produce a variety of nutrient combinations depending on the manure production process. Focusing on the nutrient levels forces a knowledge of the nutrient levels in a producer's manure products. This enhances the opportunities for markets to develop.

It is also important that regulations on manure practices credit producers who are marketing their manure products. Recent regulations in Iowa allow for the land application requirements to be relaxed, if proof of marketing intentions can be demonstrated (DeGooyer, 1996). This is a great innovation. Other states allow marketing to occur, but a producer must still meet the land application requirement and demonstrate that acreage is available to apply the manure at the regulated amount.

Know the Market Demand for Manure Products

Market demand represents the preferences of manure buyers. Three traditional manure product markets are fertilizer, feed and energy. These are fairly straight forward because feed is composed of nutrients (fertilizer) and energy.

Marketing manure products moves the problem off-site, and potentially out of the watershed, rather than concentrating it on-site as implied with the zero-effluent discharge language of the NPDES permitting language. Using broiler litter as an example, Figure 1 illustrates that higher value manure products allow manure products to be moved outside of a nutrient sensitive watershed economically.

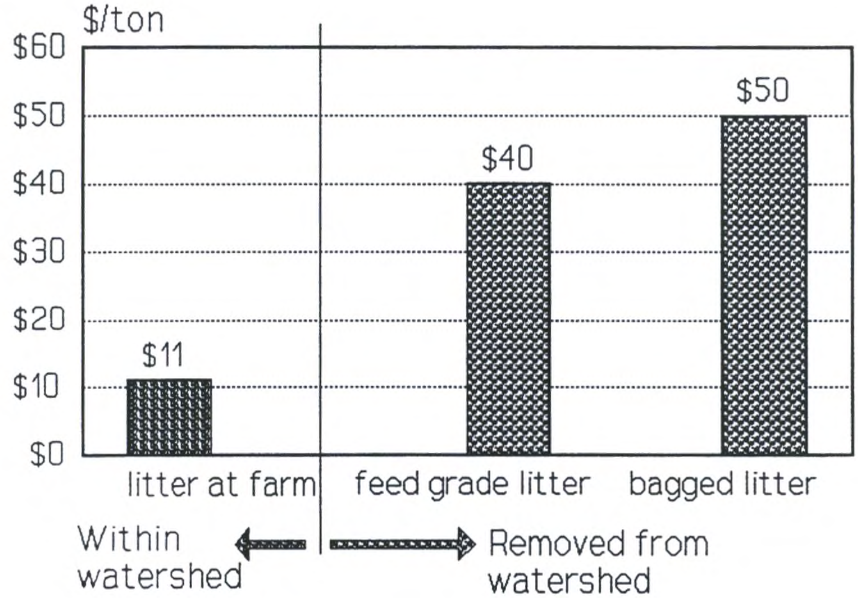

Figure 1. Prices of broiler litter for various broiler manure products.

COUNT YOUR MONEY

There is a positive social demand for manure products which can potentially enhance producer revenues. There is also a negative social demand for bad manure products. This is currently being expressed through constricting laws and regulations with which livestock producers are faced. These laws result in high costs of compliance, litigation, and a general attack on commercial livestock production. Agriculture has lost much of its influence in society and we must act to change the image of manure into a desirable good rather than a social liability. This shift to a market driven environmental paradigm will remove livestock producers from the negative environmental image they currently battle.

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UTILIZING SPENT HEN AND NORMAL FLOCK MORTALITY

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There is an economic opportunity that has changed in magnitude from a mere increase in the cash flow figures to one which may affect several management decisions. This is why there is a need to consider different means of utilizing both the normal flock mortality and also the laying hen at the end of her productive life. Not too long ago, buyers would bid for mature spent laying hens as a source of natural flavoring for inclusion in certain processed poultry meat dishes. As producers used more least cost formulating methods, physical bone strength in older hens decreased. Bone fragments in the processed meat became a problem. As the broiler industry grew, greater numbers of broiler breeder hens became available as well as broilers that were too large for most markets. The spent hen processing industry soon learned that breeder hens were a more economical product to use due to their higher meat to bone ratio and tenderness. The young broiler's lack of intense flavor was overcome by flavoring substitutes or blending breeder hen product with it.

Laying flock managers can approach this opportunity in today's economic picture in one of two ways. The first and most preferable is to minimize the losses. The second is to factor a disposal cost into the cash flow. We can minimize economic losses by converting spent hens and also mortality into a feed ingredient for animal and poultry diets. The nutritional quality of that ingredient will depend upon the method of conversion, whether it is processed as fresh product, rendered, fermented or processed with or without feathers. The other and definitely less desirable disposal method is to simply bury or incinerate mortality and spent hens. This also includes converting them by composting into a fertilizer material for a soil amendment.

Each of these approaches has potential for economic success or failure, as well as an effect upon the environment. Many methods are being explored to meet this challenge. Some utilize older technology that has been updated for today's needs. Others are trying to develop new technology that is more economically effective. The following information is presented with the idea that somewhere, one or more systems will emerge for spent hen and mortality utilization that is both feasible and profitable.

ALTERNATIVE MARKETS, SCHEDULING, TRANSPORT AND HANDLING OF SPENT HENS

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Spent hen prices have declined in recent years. The difficulty of scheduling spent hens into processing plants has increased. Processors have cut back their processing time to match demand for the finished product.

CONTRIBUTING FACTORS

Today's lighter spent hen yields only about 16 percent de-boned meat or approximately one half pound per hen. The cost of processing results in a product which costs the consumer over 2 dollars per pound. Bone contamination is high.

FUTURE CONCERNS

USDA is considering a rule to prohibit the use of mechanically separated meat from mature chickens in baby food.

Proposals to phase out commodity purchases and replace them with block grants to the state for school lunch and other feeding programs threaten a program which currently uses over 20 percent of our spent hen meat.

ALTERNATIVE MARKETS

Midwest UEP has been investigating alternative markets for spent hens. Alternatives include: burying, composting, on farm rendering, extrusion, rendering at existing facilities, pet food and other avenues.

We have investigated the nutrient value, digestibility, and feeding relationship to other products. Whole hen meal is higher in protein than meat and bone meal and poultry by product meal. It has a favorable amino acid balance, a standard pepsin digestibility value of 94.8% and an estimated feed value of 170% of 48% soybean oil meal. The product has substantial value when incorporated into the diets of broilers, turkeys, laying hens, swine and also ruminants.

REMOVAL FROM LAYING HOUSES

An important part of the study of alternative markets was the removal of the birds from the laying houses. Producers place a very strong premium on being able to to remove the birds quickly, efficiently and with an efficient, humane method of euthanasia.

We have developed an euthanasia cart. The cart is based on a simple system of charging the cart with CO_2. The birds are removed from the cages and place into the cart. The cart is then recharged inducing death in less than 60 seconds. The carts are wheeled to the end of the house where the dead birds are dumped into a truck for transport. This system can remove 50,000 hens in 8 to 10 hours.

RENDERING IN EXISTING PLANTS

Rendering plants with batch cookers are able to treat the feathers to improve digestibility. Rendering plants with proper equipment to treat the feathers are willing to work with our industry and add equipment to other plants based on our ability to obtain commitments from egg producers of a steady flow of spent hens into their plants.

Returns

The plants will remove the fat, crediting the producer with the value and offer on option of:

A. Charging a processing fee and returning the whole hen meal to the producer to be fed in the ration.

B. Selling the meal at current market prices and returning the balance to the producers after deducting costs.

At present, the product is purchased by the renderer in relation to meat and bone meal. Present meat and bone meal prices will provide a fairly low return to the producer, zero to one cents per pound at the farm, depending on distance from the renderer. However, nutritionists feel the product has greater value to the producers when fed to their laying hens. Depending on outdoor temperature, the renderers need to receive the dead birds within 4 to 5 hours, a little longer in cold weather, which will limit distance from the rendering plant. We currently have over 50 of the euthanasia carts in use with approximately 3.5 million pounds monthly going to existing rendering plants through our program.

MINK FEED

Another alternative currently being utilized is whole spent hens to mink ranchers.

Fresh Frozen

We are currently supplying hens to mink farmers, removing them from the house in the euthanasia cart and delivering the dead fresh hens into the mink producers dump truck. The mink producers are transporting and grinding and incorporating into their ration fresh, refrigerated and frozen. This alternative market is currently returning two and three quarters cents per pound live weight at the farm to the producer. Estimates are that mink producers in the Midwest can utilize approximately eight million spent hens annually in the fresh and frozen form.

Rendered Product to Mink

An additional market being explored is that of feeding the dried rendered product to mink to replace fish meal and other more expensive forms of protein. Preliminary results indicate very good acceptance and results. This will result in an additional substantial volume of product moved to mink ranchers.

Value of Alternative Markets

Alterative spent hen marketing will aid producers by removing a portion of the fowl that is presently going into live processing plants which will increase the price that these plants pay for spent hens. Alternative options allow producers to remove spent hens earlier than scheduled when the occasion warrants, which is almost impossible with our present system. This flexibility can have dramatic effect on the price of shell eggs, by enabling producers to adjust supply to demand with better timing.

Results

We are very pleased with the results of our alternative spent hen marketing. We have improved the returns to producers, particularly in the west north central area from zero to negative returns for spent hens to positive returns of one to three and one half cents per pound live weight at the farm.

We are currently taking commitments for additional rendering facilities and are continuing to explore other alternative markets for spent hens.

TABLE 1. Analysis of spent hen meal

Moisture	2.1%
Protein	69.9
Fat	9.1
Fiber	1.1
Ash	16.8
Calcium	5.16
Phosphorus	2.47
Chloride	.56
Salt based on Chloride	.92
% Standard Pepsin	94.8
% DIL Pepsin	84.3

*AGP Limited
12/08/94

TABLE 2. Amino acid profile

Lab Identification #:	OW 8369
Sample Type:	RENDERED FOWL, DARLING-DELAWARE
Project Number:	BRUCE R. BEHREND, Ph.D. AGRI-TECH

Protein:	69.9
Moisture:	2.3

Reported as: Amino Acid	Gram Amino Rep 1	Acid/ 100 Rep 2	Grams Rep 3	Sample Mean	(as is basic) Std Dev	CV
Tryptophan	0.552	0.570	*****	0.561	0.013	2.269
Lysine	3.889	3.976	4.060	3.975	0.086	2.155
Histidine	*****	*****	1.991	1.991	*****	*****
Ammonia	1.026	1.069	1.038	1.045	0.022	2.143
Arginine	4.591	4.623	4.687	4.634	0.049	1.056
Aspartic acid	5.615	5.608	5.648	5.624	0.022	0.385
Threonine	2.688	2.647	2.647	2.661	0.024	0.893
Serine	3.375	3.281	3.167	3.274	0.104	3.178
Glutamic acid	9.080	9.041	9.171	9.097	0.067	0.732
Cystine	0.809	0.811	*****	0.810	0.001	0.115
Glycine	6.656	6.624	6.703	6.661	0.040	0.595
Alanine	4.565	4.561	4.576	4.567	0.008	0.178
Valine	3.368	3.471	3.577	3.472	0.104	3.001
Methionine	1.310	1.315	*****	1.313	0.003	0.226
Isoleucine	2.663	2.733	2.802	2.732	0.070	2.549
Leucine	4.870	4.952	5.024	4.948	0.077	1.555
Tyrosine	*****	*****	2.016	2.016	*****	*****
Phenylalamine	3.209	3.215	3.250	3.225	0.022	0.692
Taurine	0.372	0.372	0.376	0.374	0.002	0.651

Rep 1 and Rep 2 - Performic acid oxidation (true cystine-methionine values).
Rep 3 - 6N HCL hydrolysis only (true tyrosine value)

AGP Limited
Agri Research and Lab Group

CALCULATING RENDERED SPENT HEN RETURNS

Example: 45,712 hens @ 3.5# = 160,000# Live Weight

Yield* 10% Grease = 16,000# 24% Meal = 38,400#
* + or - depending on feeding program (note fat value)

Cost to Render	160,000# @ $.035/#	=	$5,600.00
Credit for Grease	16,000# @ $.1725/#	=	-2,700.00
	Meal Cost		$2,840.00
	Per Ton		$ 147.92

Freight Costs @ $1.10 per Mile

	50 Miles	100 Miles	150 Miles
Hens in	$440.00	$ 880.00	$1,320.00
Meal Out	110.00	220.00	330.00
	$550.00	$1,100.00	$1,650.00

Frt Cost/ton of meal	$ 28.65	$ 57.30	$ 85.95
Meal cost/ton	147.92	147.92	147.92
Del. Meal Cost/ton	$ 176.57	$ 205.22	$ 233.87

Returns: If your computer values spent hen meal in the ration at:

Value per Ton			Return per Pound live Wt.		
50 mls*	100 mls	150 mls	50 mls	100 mls	150 mls
$176.57	$205.22	$233.87	$ .00	$ .00	$ .00
259.90	288.55	317.20	.01	.01	.01
343.23	371.88	400.53	.02	.02	.02
426.56	455.21	483.86	.03	.03	.03

*Mls = miles.

If your computer doesn't work that way:

Dr. Joe Vandepopuliere at the University of Missouri conservatively calculates the value of spent hen meal at 1.7 times 48% soybean meal. By his calculations:

If 48% Soybean Meal is	Spent Hen Meal is Worth
$ 250/ton	$ 425.00/ton
230	391.00
220	374.00
210	357.00
200	340.00
190	323.00
180	306.00

EXPERIENCES AND CHALLENGES USING SPENT HENS FOR MINK FOOD

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Moyle Mink Farms
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Moyle Mink Farms has been producing mink for 70 years in the state of Idaho. At present we have eight farms in operation.

Twenty five years ago the last poultry processing plant closed in the intermountain area. As this was the last plant with spent hen killing capacity, the local egg farmers were faced with long trucking distances for disposal of their spent hens. Moyle Mink Farms was approached by Merrill Hatchery of Paul, Idaho, to see if spent hens could serve as mink food for the local mink industry. Feed trials were initiated and it was found that spent hens with feathers could be used at a 20% inclusion rate in mink food. At a later date, a 60% inclusion rate was found to be successful using spent hens without feathers.

Today, the spent hens are collected at the egg farms using two different methods. The first and oldest method is the use of a combination of truck, power generator, refrigerated cooling tank, and electric grinder. Upon arrival at the egg farm the spent hens are ground into a refrigerated tanker truck and then transported to our mink farms for inclusion in our mink food. Due to the weight of the equipment needed, only 5000 spent hens can be moved from the farms with each visit. This limits this method to a distance of not over 300 miles.

The second and newest method is the use of a standard crate trailer with removal of the live hens at the farms. Upon arrival of the filled crate trailer at the mink farms, the spent hens are then ground, refrigerated and included into our mink food. With the live crate trailer and the ability to transport 10,000 spent hens at a time, our range for spent hen pick up and delivery has been greatly increased with this method.

Some mink operations will quick freeze the ground spent hen product into naked block form for longer storage. Naked blocks are formed by freezing the product in a mold and then stacking the frozen blocks of product on pallets secured with shrink wrap. A quick chill or freeze is important to inhibit bacterial growth in the spent hen product. As an added precaution mink are routinely vaccinated against botulism. It has been found that digestibility is increased with a finer ground product than a coarse ground one. Mink are unusually sensitive to biotin deficiency. When feeding spent hens to mink, biotin is supplemented to overcome the negative influence of avidin from raw eggs within the hens on biotin availability.

Today the majority of the spent hens in the intermountain area are being sold as mink food. At present three different mink groups are conducting the same type of use of spent hens. As there is more demand for spent hens than there is supply in the intermountain area, the ground spent hen product is being used feathers and all below a 20% inclusion rate in mink rations.

A new mink facility is presently under construction in the state of Chihuahua, Mexico. Once in operation it is the intent to reach into Mew Mexico, Colorado, and Texas for live spent hens. As labor is cheaper in Mexico, a defeathering system is being installed so that the spent hens can be used at 60% levels in the mink food. At these high levels, the Mexican operation will eventually consume millions of spent hens.

We feel that the conversion of spent hens into mink manure which is spread on adjoining pastures is the most natural approach to solving a possible environmental problem. Many people have suggested many different solutions for spent hen disposal. Most require a subsidy to function. Ours does not. In fact, we make a profit doing it.

SPENT HEN UTILIZATION - A LOCAL RENDER'S PROSPECTIVE

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The utilization of spent hens has been a problem in the poultry industry for many years. Historically, spent hens have possessed value in the edible food chain utilizing various processing conditions by commercial food companies. However, the products produced utilizing spent hens tended to be variable depending upon the strain of commercial layer, age of the bird and the feeding regiment prior to processing. More recently, surplus poultry meat, available from the specialty processing of certain parts for fast food restaurants, has resulted in the meat derived from spent hens becoming less attractive, both in use and price.

INDUSTRY NEEDS - LONG-TERM SOLUTIONS

During the 1990's, the edible value of spent hen products has been very unpredictable due to widely changing economics, eating practices and habits. Because the demand for spent hens has been extremely volatile and the value received for spent hens has been very unpredictable, we were interested in developing a process to provide an alternative solution for the industry. Darling has been very proactive with UEP, and its producers, to find solutions to the spent hen dilemma.

SPENT HEN MEAL - DARLING INTERNATIONAL

In order to provide an alternative solution to the poultry industry for the utilization of spent hens, Darling International has developed two processing plants for the production of spent hen meal.

We are in the early infant stages of development of this commercial process. We have experienced the same problems that have plagued the food industry in recent years. Our results indicate that the end product will vary according to the strain of layer utilized, age of the bird, and the feeding regimen prior to processing. And, since the process is highly capital intensive, we have had to work closely with producers in order to obtain sufficient production volume.

We started utilizing spent hen meal from our production plants early in 1996. The feeding trials indicate that this product has a very good acceptance in layer diets. We will continue with these feeding trials on a long term basis to increase our database on utilization of spent hen meal. We feel that in the longer term, commitments by producers to consistently use our services for at least a portion of their production, will ensure the potential of an economic cost solution to the disposal of spent hens. Without long term cooperation, we will both lose.

The typical nutrient analyses are presented in Table 1. Although we do experience variation due to the type of product received at the processing plant, the values presented in Table 1 are obtainable on a routine basis.

TABLE 1. Typical analyses - spent hen meal

Nutrient	Percent
Crude protein	69.0
Pepsin digest protein	67.0
Fat	12.0
Ash	15.0
Calcium	4.5
Phosphorus	2.5
Salt	0.9

The typical amino acid analyses for spent hen meal are presented in Table 2. The amino acid analyses have been utilized in formulation of layers diets and other poultry diets.

Table 2. Typical amino acid analyses - spent hen meal

Amino Acid	Percent
Lysine	4.00
Methionine	1.40
Cystine	0.70
Methionine + Cystine	2.10
Tryptophan	0.60
Phenylalanine	2.70
Tyrosine	1.75
Leucine	5.00
Isoleucine	2.85
Threonine	2.65
Valine	3.50
Histidine	2.05
Arginine	4.50

We will continue to enlarge our database through analytical analyses and experimental feeding trial results to further refine the economic values for spent hen meal.

SPENT HEN UTILIZATION IN THE RENDERING INDUSTRY

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In the fall of 1994, American Proteins, Inc. (API) was approached by Dave Reeseman, President/General Manager of the Southern United Egg Producers as to the possibilities of their organization providing spent hens to the rendering industry.

As per this meeting, the following information was provided relative to the availability of raw material supplies:

State	# Hens (Million)	Estimated Disposal over 12 Month Period
Alabama	5,400	2,700
Arkansas	6,740	3,370
Florida	8,875	4,437
Georgia	10,280	5,140
Kentucky	1,800	900
Louisiana	800	400
Mississippi	2,350	1,175
North Carolina	6,460	3,230
South Carolina	3,900	1,950
Tennessee	500	250
Virginia	1,600	800
Totals	48,705	24,352

It was stated that the number of birds disposed of weekly were on a reasonably equal basis, with the exception of January, April and July at which time the disposal rate would be higher. Based on these facts and the feeling that it was possible to get a commitment from 25% of the egg producers, 409,770 pounds per week of spent hens would be available to the rendering industry in the southeast. It was also suggested that it would not be financially feasible to expect the egg producers to kill and remove the feathers.

Based on the above data, it was decided by API to install receiving and grinding equipment at their three facilities in Cumming, GA, Cuthbert, GA and Hanceville, AL to process spent hens.

The following arrangements were agreed upon by American Proteins, Inc. and the egg producers:

1. API would provide a trucking service for a fee or the egg producer could haul the dead birds at their discretion.
2. The producer would be responsible for placement of the birds in trailers that have solid tarps to facilitate gassing.
3. API would pay the producer based on the market prices of Poultry Meal, Poultry Fat, product yield and a rendering processing fee.
4. API would accept up to 120,000 pounds per day of spent hens at each facility.

Other Considerations

1. Due to the lack of a formal commitment by the egg producers, it was necessary to minimize capital investment.

2. Since batch hydrolyzation was not possible because of the lack of available capital dollars, the nutrient values in the feathers would not be available.

3. The feathers by not being hydrolyzed, would absorb fat, thus increasing the fat residual in the poultry meal and decreasing the amount of fat available for sale. Traditionally the fat market is higher than the poultry meal market.

4. The unhydrolyzed feathers in the poultry meal is an undesirable characteristic by the end user.

SUMMARY

To date, only the Cumming facility has received spent hens from the egg industry of any significant volume. This confirmed our decision of not making large capital investments to handle the product without some formal, long-term commitment from the egg producing industry.

Although the current arrangement between American Proteins, Inc. and the Southern United Egg Producers appears to be a viable alternative for disposal of spent hens, there are future possibilities to increase profitability of this production for both the rendering and egg production industries. In order for this to occur, the following will have to take place:

- The egg producers will have to be willing to make long term commitments to dispose of spent hens.
- The rendering industry will have to be willing to make the necessary capital investments required to best utilize this product.

A concerted effort by both the rendering and egg production industries must occur to research and develop value-added markets.

OVERVIEW OF SPENT HEN ALTERNATIVES

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The population of Leghorn hens in the U.S. is approximately 250,000,000. Throughout the year, egg production is adjusted through molting programs and replacement of older "spent" hens with young pullets. Considering these programs and other variables some 130,000,000 hens are surplused each year. For many years these hens have been processed in a regular poultry processing plant to produce an edible carcass, offal, blood and feathers. The carcass was further processed for human consumption and the by-products were processed to produce feedstuffs for animal use. There are a variety of ways the spent hen carcass can be utilized. The hen can be canned and cooked. It can be cooked and de-boned with the broth used in soup and the meat in soup and pot pies. The meat can be diced and used in salads or other combination dishes.

This method of spent hen utilization has worked very satisfactorily for many years. What has happened to bring about the need for a major change in spent hen disposition? The industry is constantly emphasizing improved efficiency. In the case of Leghorn hens this resulted in a smaller body yielding a decreased amount of muscle tissue. When these hens are processed the meat yield is minimal, yet with processing costs per unit of meat yield increasing. In addition there is a problem with more brittle bones in these mature fowl increasing the vigilance required to remove bone particles in the edible portions. Simultaneous with these changes in the egg industry, the broiler and roaster production efficiencies have increased dramatically. The chicken broiler was bred to grow rapidly, convert efficiently and produce a large amount of meat that can be used in place of spent hen meat. This meat has excellent qualities for use in a variety of products and the bone particle problem is minimal. Since the segment of the food industry which historically utilized the spent hen carcass has switched to broiler or roaster products, the bottom line economics must favor the use of broilers and roasters.

SPENT HEN ALTERNATIVES

There is a variety of potential alternative uses for spent hens. This presentation will concentrate on uses in animal diets.

Human

Even though the use of spent hens for human food has decreased in recent years the potential for this market exists. It is possible that new products and uses can be developed to make better use of the spent hen. The profitability of these developments will determine the amount paid for the hens and the market direction. These possibilities should not be overlooked by industry and the scientific community.

Non-Human

By-products from poultry processing have been used as feed ingredients for many years. Increasing materials concentration and improved manufacturing systems and techniques make these products very competitive. These ingredients are produced with high quality standards and are desired by the feed milling industry. A logical route for spent hen utilization would be as a feedstuff in the animal industry (Haque et al., 1991). There is a variety of specialty feeds as well as conventional poultry and animal feeds.

SPENT HEN PROCESSING PROCEDURES

In all industries, economics play a major role in determining the feasibility of new product production and utilization. In the spent hen situation there is a composite product consisting of meat, bone, fat and feathers that must be converted to usable products. This requires special consideration with respect to transporting, killing, grinding, heat treating and storage.

Transporting

The hens can be transported in the conventional manner in live haul trucks to the plant where they can be humanely killed by exsanguination, cervical dislocation or with carbon dioxide. This method ensures a quality bird delivered to the plant. They can also be removed from the production cages and placed in portable cages that can be put in carbon dioxide chambers prior to loading onto the truck. Another technique would be to remove the hens from the cage and put into a cart that is flooded with carbon dioxide. The dead hens would be transported to an open top semi-trailer. The loaded trailer would then be transported to the processing plant.

Processing

There is a variety of processing procedures that can be used to convert spent hens to usable products. They will be described in accordance with the projected use of the end product.

General Poultry: This procedure utilized a Weiler and Co.(1995) grinder equipped with a ¼ inch orifice plate or an equivalent machine to reduce particle size to facilitate mixing or/and cooking. Chunking is used in conventional rendering plants. Following rendering, using a modified feather cooking process, the oil is expelled from the meal. The meal is ground to the desired particle size, screened, cooled and conveyed to a storage bin.

Other processing methods produce products containing the full fat hen. Some processes work better with reduced moisture level. In this environment the ground hen is mixed with ground corn, wheat middlings, soybean meal, etc. to reduce the moisture content. The mixture is then passed through a pellet former and heated simulating baking or is extruded under pressure-heat and dried to a 12% moisture level to ensure good storability. Some dry rendering equipment is designed to heat and dry the ground spent hen with or without mixing with a drying ingredient or forming it into a special particle. The resulting whole hen meal can be ground and stored in a bulk bin. The fat content of whole hen meal is very high and an antioxidant should be added to prevent oxidation. These feedstuffs can be fed to broilers and layers.

Specialty Animals: The meat eating animals of primary interest are mink, cats and dogs.

The commercial mink industry continues to be a significant factor in pelt production for the garment industry. Processing for mink feed is very simple. The fresh dead hen is ground and immediately frozen in 50 pound blocks and stored in a freezer until it is needed for feeding. The block is thawed immediately before mixing with other ingredients needed to make a balanced diet. The wet mash is then fed immediately.

The largest specialty animal area includes dogs and cats. Numerous products are manufactured including canned, soft moist, and dry diets. These are generally balanced diets meeting the animal's nutrient requirements. Meat products provide high quality protein and fat. The palatability factor of an ingredient plays a major role in its use. Feather meal or feathers are not generally acceptable in these diets. It is also desirable to have a low ash ingredient. These restrictions require special spent hen processing. The poultry further processing industry utilizes a unit that separates the meat from chicken frames, etc. This unit can be used to separate the bone and feathers from whole dead hens. The mechanically deboned meat (MDM) can be utilized in many of the companion animal products. It would be cooked as the total diet was processed for animal use. The residual feathers and bones could be processed through a feather processing unit producing a high protein product for use in the general animal feeding industry.

Processing ground spent hens in a fluidized bed oven followed by steeping or by extrusion produces Salmonella negative ingredients with a marked reduction in the number of aerobic plate colonies, Coliform, yeast, and mold.

UTILIZING SPENT HENS

The chemical composition was determined on a number of types of spent hen products by the University of Missouri's Chemical Laboratory. As shown in Table 1 the whole hen is high in protein and fat (process 3,4). When the fat is pressed from the meal the protein is increased markedly (process 2). Processes that require the addition of dry ingredients tend to dilute the protein and fat of the final meal (process 5,6). With the use of a mechanical deboner to process spent hens, two distinct products, 7a and 7b are produced. The MDM (7a) is higher in fat; however, the feather-bone product (7b) is higher in protein and minerals.

NUTRITIONAL EVALUATION OF SPENT HEN MEAL

Several chicken broiler studies were conducted to determine the value of spent hen meal when fed to day-old chicken broilers. A few of the levels of the spent hen ingredients that were studied are shown in Table 1. Performance records are tabulated immediately below the spent hen ingredient use levels in Table 1.

The corn and soybean meal(48) used in these experiments were stockpiled and analyzed for protein, fat, amino acids, calcium, and phosphorus. All of the test ingredients were subjected to the same analytical procedures. Diets were computed using The Brill Corporation, version 4.01 program (1987). The determined ingredient values were used to compute the diets to meet the 1994 National Research Council (1994) nutrient requirements for day-old broiler chicks.

TABLE 1. Ingredient composition of and broiler performance on various spent hen feedstuffs

PROCESS[a]	1	2	3	4	5	6	7a	7b
DM %		95.70	96.00	86.10	94.70	94.70	93.00	93.00
Protein %		62.00	41.28	42.74	29.60	29.60	45.98	55.40
Ether ext %		13.20	39.53	30.62	22.36	22.36	43.28	16.95
Ca. %		5.16	2.38	2.63	1.15	1.15	.38	7.92
Phosphorus %		2.47	1.20	1.38	1.07	1.07	.59	3.19
Lysine %		3.57	2.17	2.53	1.62	1.62	3.57	1.92
Methionine %		1.11	.73	.87	.57	.57	1.12	.63
Cystine %		.86	.84	.72	.66	.66	.61	1.41
Threonine %		2.23	1.65	1.63	1.18	1.18	1.92	1.83
ME kcal/kg		2900	4215	3741	3130	3130	4839	3056
Usage of Ingredient Produced by the Above Process								
Level in Diet %		6	6	4	12	12	6	3
Broiler Performance (0-21 days)								
Weight, g	798	764	843	778	855	831	821	819
Fd. cons, g	1036	973	1050	974	1056	1061	1029	1048
Conv. fd./wt.	1.30	1.27	1.25	1.25	1.23	1.28	1.25	1.28

[a]Process description by process number:

1. The control diet was composed of corn, soybean meal (48), fat, Methionine, vitamins and minerals. All diets met the 1994 NRC nutrient requirements for day-old broiler chickens.
2. The reduced fat spent hen meal was produced using a proprietary process by Darling International, West Point, NE 68788.
3. Full fat spent hen meal was produced using Jet Pro's (Atchison, KS 66002) proprietary process involving pelleting and a continuous hot air heated fluidized bed oven followed by steeping in an insulated drum.
4. Full fat spent hen meal was produced by Scott Equipment Company, New Prague, MN 56071.
5. A 1:1 ratio, dry matter basis, of ground spent hen and wheat middlings was processed through Jet Pro's pelleting and fluidized bed heating process.
6. A 1:1 ratio, dry matter basis, of ground spent hens and wheat middlings was processed through Jet Pro's process reducing the moisture level to 25%. The product was then processed through an Insta Pro extruder (Des Moines, IA 50322) and air dried for 48hr.
7. Whole dead spent hens were passed through a BeeHive (Sandy, Utah 84091) Food Processing Machine producing mechanically deboned meat (7a) and a feather-bone fraction (7b). Both fractions were processed in an autoclave at 20 lb. pressure for 1.5 hr. They were then dried in a forced hot air oven and ground in a hammer mill.

Performance, body weight, feed intake, and feed conversion on the products tested were as good as or better than on the control diet. All performance records were typical for 3 week-old male broiler chickens.

An evaluation of least cost diets demonstrated that full fat spent hen meal is worth from 1.5 to 1.7 times that of soybean meal (48).

APPLICATION

Spent hens can be processed using a variety of methods. The primary requirement is to start with a freshly killed hen and to have the entire spent hen meal heated adequately to reduce the bacterial count to an acceptable level. It must then be dried to 10-12% moisture so that it can be stored. An antioxidant should be added if the product is not used immediately. Meal produced from spent hens can be utilized as an ingredient in poultry and companion animal diets.

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HANDLING SPENT HENS ON THE FARM

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The decline in the traditional market for spent hens has created serious problems for egg producers. To be able to match the cyclical production characteristics of layer flocks to the seasonally varying needs of customers, egg companies must maintain carefully timed schedules of flock replacement. Failure to remove a spent flock on time because it has not been sold forces a company to hold on to unproductive hens, and creates management difficulties regarding replacement pullets which cannot be held out of production indefinitely. Egg producers need to find alternative uses for spent hens to prevent them from becoming an increasing liability. While over 100 million spent laying hens must be removed in the United States every year, the seasonal nature of the egg market concentrates their availability into certain months of the year. Moreover, spent hen flocks are owned by many companies spread out across the country. These facts make finding commercially viable alternate uses for spent hens a challenging proposition. One option in areas having a sizable animal by-products industry is to sell spent hens to renderers. Many renderers deal with large volumes of raw stock and would be able to handle the comparatively small volume of spent hens available at any given time.

Since renderers expect that hens delivered to them be dead on arrival, egg companies need to solve the problems of where and how to kill the hens. the most feasible place to kill hens is on the farm, if it can be done properly, because it would involve the least amount of handling and transportation of birds, and avoid the financial investment and regulatory compliance necessary for establishment of a separate slaughter facility. With spent hens having so little value, any killing method must be efficient and inexpensive. It must be simple so that it can be used by the unskilled crews generally hired to catch hens. Our society is concerned about animal welfare so the method to kill spent hens must also be demonstratably humane.

We considered several options for on-farm killing of spent hens. Cervical dislocation is accepted by the American Veterinary Medical Association as a means for euthanasia of poultry (AVMA, 1993). However, we did not think it feasible on the scale required to remove hens from a commercial layer house. The technique requires skill to be performed properly, and would be physically demanding if done by hand. Recent research also suggests that cervical dislocation may not induce instantaneous unconsciousness (Gregory and Wotton, 1990), so the procedure may not be as humane as originally thought.

An electrical stunner adjusted to kill could be incorporated into a compact shackle line installed on a trailer, making it possible to carry the equipment from farm to farm. if it were necessary to scald and pick carcasses immediately after killing to prepare them for a product such as pet food, the system might be attractive. However, no market is apparent which would pay the premium required to justify the costs of constructing and operating an electrical killing system so it does not appear feasible at this time.

A modified atmosphere killing (MAK) procedure using carbon dioxide (CO_2) appeared to be the best option. Research has indicated that chickens become unconscious in 20-30 seconds, and die within 2 minutes, in an atmosphere containing CO_2 at levels of 45% (Poole and Fletcher, 1995; Raj and Gregory, 1990; Raj <u>et al</u>., 1990). Carbon dioxide also has an anesthetic effect, making animals less sensitive to pain. this method of killing is considered by the American Veterinary Medical Association to be acceptable for poultry (AVMA, 1993). Other gases, such as nitrogen or argon, could be used for modified atmosphere killing, but carbon dioxide, unlike nitrogen, is heavier than air and can be contained relatively easily, and unlike argon, is fairly inexpensive. Carbon dioxide also would be less difficult to use in an on-farm situation because it will kill at lower concentrations than the other two gases, thereby not requiring maintenance of such an extreme dilution of air in the container used for killing.

Modified atmosphere killing does not use poisonous gases and so does not directly threaten human safety. The method dilutes air with a gas so that hens cannot take in enough oxygen to survive. A poisonous gas such as carbon monoxide, on the other hand, has a direct lethal metabolic effect and can kill even in the presence of enough oxygen to keep hens (or people) alive under normal circumstances. it would be dangerous to use such a gas for on-farm killing of spent hens.

MODIFIED ATMOSPHERE KILLING CART

The design and operation of modified atmosphere killing (MAK) carts has been described in greater detail in Webster et al. (1996). Our MAK carts consist of closed units (40-45" H x 54" L x 20" W) mounted on sturdy rotating casters. Two smaller boxes sit on the main body of the cart and have spring-loaded clear lexan doors opening inward facing each end of the cart. These form entry compartments from which hens drop down into the main compartment of the MAK cart. An unloading door, hinged at the top and running the length of the cart, opens up about 2/3'rds of one of the long sides. The floor inside is sloped so carcasses slide out easily. Interior seams are sealed and rubber or felt liners are fastened around door edges to minimize gas escape from the cart.

Carbon dioxide is delivered from a 20 lb cylinder mounted on one end of the MAK cart through PVC tubing to two levels inside. The tubes in the interior, one near the floor and the other about 10" from the top of the cart, run the length of interior and are perforated every few inches with 1/4" holes. A cutoff valve on the MAK cart controls the delivery of CO_2 into the interior. We found that a cylinder mounted in an upright position only dispenses about 2/3'rds of its contents because of a pressure drop in the cylinder, but when it is mounted upside down without a regulator it can be emptied during use. In this arrangement, the CO_2 expands from a liquid to a gas as it travels through the PVC tubing into the MAK cart. This chills the tubes so care must be taken not to release the CO_2 so forcefully that the tubes become jammed with CO_2 snow, causing them to burst from pressure buildup. In actual use, this has not been a problem. The line connecting the cylinder to the cutoff valve carries liquid CO_2, so it and the cutoff valve should be strong enough to withstand at least 800 psi.

The MAK cart is rolled into the aisles of layer houses and hens placed inside immediately after being removed from their cages. It is best to prefill the cart with CO_2 so that the first hens inside are stunned quickly. Thereafter, CO_2 must be added as needed to be sure that hens are stunned before they are overlain by hens loaded after them. Hens settle down quickly if the levels of CO_2 are high enough, so visual observation of activity in the cart, made possible by the lexan loading doors, is the best guide for determining when more CO_2 is needed. With a final flush of CO_2 at the end of loading, the killing process continues as the cart is being rolled out of the house. Little waiting time is needed on the dock to ensure that all hens are dead before the cart is emptied. If used properly, one 20 lb cylinder can kill about 1500 hens.

HUMANE KILLING

A supply of CO_2 must be carried on the MAK cart itself. Concentrations of CO_2 greater than 30% are needed to ensure that stunning and death are sufficiently rapid (Raj and Gregory, 1990). Figure 1 shows changes in CO_2 levels for several trials in which the gas was added only before loading began. In three trials, one 15-second flush of gas was unused and the level of CO_2 declined to 30% in about 2.5 minutes after the first hens were put into the cart. In trails 4 and 5, CO_2 was injected into the cart an additional 1 and 3 occasions (not timed), respectively, to achieve higher initial concentrations, and even so, CO_2 dropped to 30% in less than 4 minutes after loading began. In these trials, the loading rate would have filled the cart in about 7 minutes. This is represented in Figure 1 to emphasize the point in the loading process when CO_2 would drop below the critical level. Table 1 shows data for trials in which oxygen (O_2) levels were measured. An oxygen concentration of 15% corresponds to a CO_2

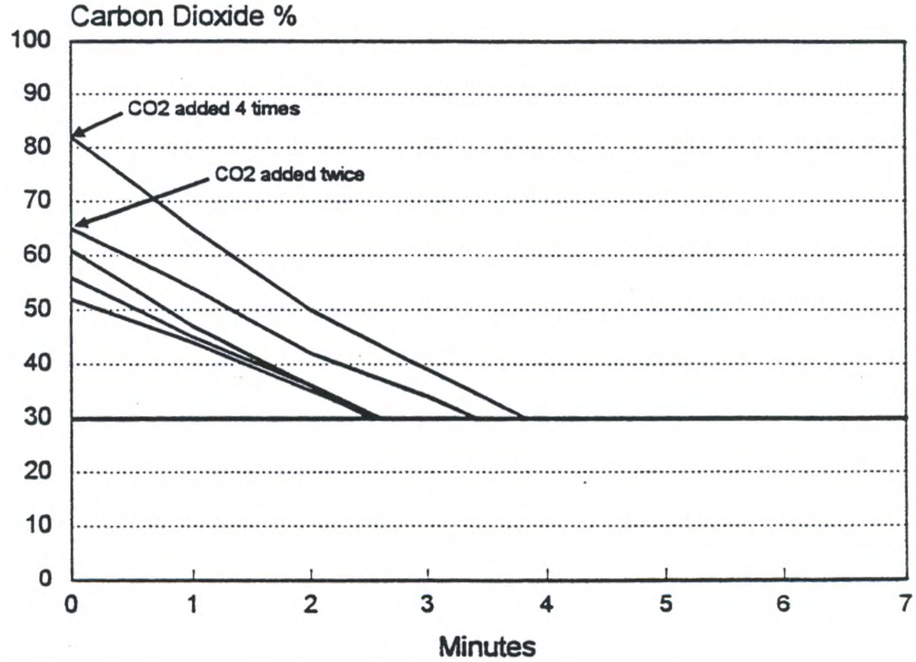

Figure 1. Changes in CO_2 levels during loading of the MAK cart (5 trials). CO_2 was added only before the start of loading. Loading was at a rate which would have filled the cart in 7 minutes.

concentration of about 30%. Hens will remain conscious in an atmosphere having 15% oxygen. Two loading rates were tried, one which would have filled the cart in 7 minutes (slow) and the other in 5 minutes (fast). Carbon dioxide was added as described for the trials depicted in Figure 1, with the gas being injected twice in trials 2 and 3 of the slow load and fast load, respectively. Oxygen levels rose quickly after loading began and did so more rapidly when loading proceeded faster. When loading was slow, 15% oxygen was reached in 2.5 minutes or less. When it was fast, the time taken to reach 15% oxygen was reduced to no more than 2.1 minutes, even when an extra effort was made to achieve low starting oxygen levels by injecting CO_2 twice. Air evidently entered the MAK cart with every hen pushed in.

TABLE 1. Changes in O_2 levels during loading of hens into the MAK cart. CO_2 was added to the cart only before the starting of loading.

Loading Time	Trial	Starting O_2 (%)	Time to 15% O_2 (minutes)
7 minutes	1	9.5	2.0
(Slow)	2[a]	7.8	2.5
5 minutes	1	10.9	1.5
(Fast)	2	11.9	1.2
	3[a]	7.3	2.1

[a]CO_2 injected twice to achieve lower initial O_2 concentration.

These data suggest that if CO_2 is not added periodically during the loading process, half the hens put into the cart will be overlain, while still conscious, by hens loaded after them. Some will smother. Others will be forced to endure until the dart is rolled out of the house and CO_2 is added to kill the surviving hens. A MAK cart used properly is more humane than traditional treatment of spent hens because the hens are spared the stresses of transportation, exposure to weather, waiting, and shackling before slaughter. Instead, they quickly go unconscious and die within minutes of being removed from their cages. Conversely, improper use of a cart by not adding CO_2 as needed can only be characterized as inhumane.

Figure 2 shows the profile of CO_2 levels in a MAK cart when the gas was added at 2-minute intervals during a 7-minute loading trial. Even on the one occasion when CO_2 fell to less than 30% there was little likelihood of hens being overlain while still conscious because CO_2 levels were restored shortly thereafter. Nonetheless, the figure supports our contention that visual observation is the best way to determine when to

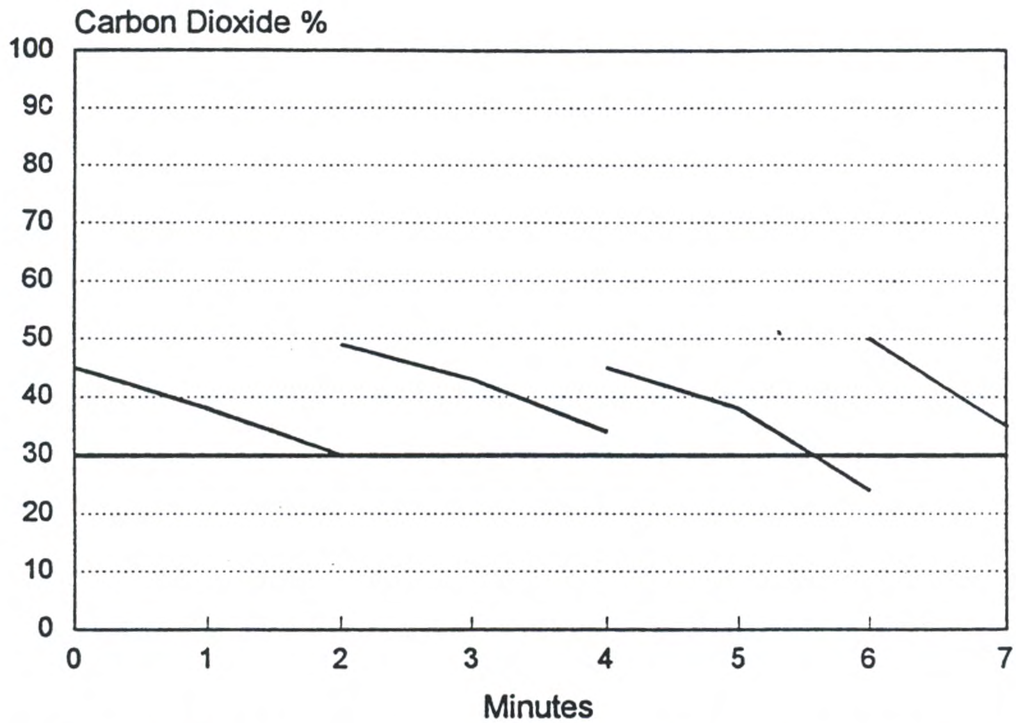

Figure 2. Changes in CO_2 levels during loading of MAK cart. CO_2 added at 0, 2, 4, and 6 minutes.

add CO_2 during loading. The speed at which a crew loads a cart determines the rate at which gas levels change inside, making it difficult to prescribe a schedule for adding gas that would ensure hens are stunned in a timely manner, yet not be wasteful of CO_2. If a person cannot see inside a MAK cart, they have no way of knowing if CO_2 levels are adequate. Having windows on the cart achieves two purposes. It makes it possible to add CO_2 only when necessary, minimizing a cost component of the killing procedure, and it creates a quality control opportunity to ensure that hens are killed humanely. The best way to put windows on a cart is to make them of a clear, tough material such as lexan and use them as loading doors.

GENERAL NOTES

Our MAK carts hold about 250 hens. A pair of catchers fills one in 5-8 minutes, at least as fast as a traditional hanging cart can be loaded, which holds about 144 hens. It should be possible to offset the cost of the CO_2, which is about $0.005 per hen killed. Assuming that the number of loads a crew could remove from a house in a given time was the same using hanging carts or MAK carts, revenues would be proportionately higher using the MAK carts because more hens could be removed per hour, minus the cost of the gas. At $0.04/hen, the return per cart load would be $8.75 for a MAK cart vs $5.76 for a hanging cart. The relative economic advantage of using MAK carts depends of course on labor costs, the cost and capacity of the MAK cart being used,the cost and efficiency of the system used to transfer hen carcasses onto a truck trailer, and the price of CO_2. Cost comparisons has no recourse but to kill hens on the farm to be rid of a spent flock.

Many of the spent hens in northern Georgia are now being sent to a rendering plant. The catching company that operates in this part of the state uses a set of MAK carts to kill these hens on farms. Much of the egg production in Georgia is on contract farms, which requires the catching crew to transport their equipment from farm to farm. While the on-farm killing procedure is working very well, it cannot truly be efficient unless it is integrated with a materials handling system to transfer hen carcasses from the MAK carts to truck trailers. This has proven to be a challenge because of the diversity of ways farms are laid out. Some farms have loading docks and some merely ground level cement slabs. On many farms, the loading platform can be approached from only one angle. An ideal farm layout would have enough room in front of a loading dock for a dump trailer to be parked sideways to the dock and then moved sufficiently so that carcasses could be piled evenly over the length of the trailer. From a high rise dock, spent hens could be dumped directly from MAK carts into the trailer. From a 4-foot dock, the hens could be dumped into a conveyor that is long enough to reach over the side of the trailer. Since the situation in Georgia is not usually ideal, we are having to develop a system that can be adapted to any farm layout. In its final configuration, this will probably involve a conveyor to deposit hen carcasses into the back of a live-bottom trailer, which handles its own load distribution, and a platform scissor lift to raise MAK carts high enough to dump into the conveyor's hopper when working from ground level. These pieces of equipment and the MAK carts must be sufficiently durable that they can be depreciated over several years to minimize the equipment component of the cost of flock removal.

Interestingly, the sale of a substantial number of flocks to the renderer has tightened the market for spent hens in Georgia. Fowl processors have become interested in competing for these birds at times, thus firming up their value.

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ROLE OF COMPOSTING IN AGRICULTURE

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For many farmers, making compost and applying it to soils is an integral part of the transition to more sustainable and profitable crop production. Farmers are changing methods because of steadily growing concerns over high costs of chemical inputs, declining soil fertility, increasing problems with groundwater contamination and side effects on their personal health from pesticide applications.

Agricultural research centers are spending more time and effort to help agriculture and society achieve the ambitious goals of environmental quality, food production and economic success. Increasingly, research is being directed toward biological control, soil improvement and organic waste management. When it comes to "best management practices" for organic residuals, composting is cited as an effective method.

As solid waste managers in cities and states have come to recognize the role of composting as a way to divert organic residuals from landfills, the importance of producing a quality compost with high value in agriculture has correspondingly become recognized.

For over 30 years, <u>BioCycle,</u> Journal of Composting & Recycling, has reported on how to make the best use of composting as a method, and compost as an end product. Many articles have described how farmers utilize this method. The Birkenfeld brothers provide an excellent example on their 3,500 acres of farmland near Tulia, Texas. Some 12,000 tons of composted feedlot manure are applied to their soil every year, and they also sell another 10,000 to 15,000 tons of compost, making that part of their operation a significant income generator. "We were using a lot of chemicals in a vain effort to control insects, and lots of fertilizer trying to keep yield up. There had to be a better way," says Bob Birkenfeld. Compost turned out to be that "better way."

Manure is what got Robert Keller to evaluate composting -- lots and lots of manure. Soil nutrient levels on his farm in Lancaster County, Pennsylvania had been rising for some time, and continued to rise even after he stopped applying commercial fertilizers. Finally, he realized that manure was a big part of the problem. "When my father and I were farming together in the 1970s, there was never such a thing as too much manure," he says.

Back then, the father and son operation had 50 cows and around 45,000 layer hens on 250 acres. Today, Keller has 200 head of cattle and 70,000 layers on a 95 acre farm. He rents an additional 45 acres of cropland for corn, small grains and soybeans which, in addition to his own land, also get applications of manure, but it still wasn't enough for the 2,500 tons of manure generated by the farm each year.

The excess manure also had created a fly problem and the insecticides being used for control were becoming less effective. He began cleaning out the layer houses every five to seven days to break the 'flies' egg cycle. That provided better fly control, but required more manure handling and still didn't solve the problem of excess volume. "I was coming to the conclusion that we would have to move manure off the farm," says Keller, "but that can get very sloppy and is just not a very viable alternative in my mind."

While wrestling with these management issues, Keller began to analyze how composting could convert the nutrients in manure into more stable organic forms that release slowly and are less susceptible to leaching. "After some investigation, I began to think composting might be a good way to turn this manure into something much more desirable -- as well as marketable," he says.

BLENDING COMPOSTS WITH FERTILIZERS

A substantial portion of the nitrogen fertilizer needs of wheat could be met by compost blended with fertilizer, according to studies conducted by the U.S. Department of Agriculture and the Pakistan Agricultural Research Council. The research was designed to determine the effects of compost, fertilizer combinations on crop yields, utilizing composts made from agricultural and industrial wastes.

"This greenhouse experiment designed to vary compost and fertilizer nitrogen ratios demonstrates that 25 to 50 percent of the N fertilizer requirement for wheat can be substituted using sugar industry and jute mill industry composts," writes L.J. Sikora of the USDA's Agricultural Research Service and M.I. Azad of the Ayub Agricultural Research Institute in

Pakistan. Sikora and Azad cite these two reasons for the importance of the findings:

"First, the environment may benefit because less of the highly mobile, mineral fertilizers which may pollute groundwater are added to fields. Second, small versus large compost amendments give positive responses which translate into compost being available to more users. The benefit to the farmer in reducing fertilizer costs and to the environment in reducing fertilizer enrichment of groundwater is potentially great when using compost/fertilizer combinations. Field studies should be designed and conducted like that reported here to determine the fertilizer value of compost."

COCOMPOSTING FARM AND MUNICIPAL WASTES

The objectives of recent studies in Maryland's Chesapeake Bay region were to: Produce an organic soil amendment combining poultry litter and municipal solid waste (MSW) compost which would supply adequate nutrients for crop production; Evaluate the compost characteristics of varying combinations of poultry litter and municipal compost; and Evaluate nutrient release characteristics when applied to farm fields. Dr. Leslie Cooperband of the University of Maryland's Wye Research and Education Center conducted the project.

According to Dr. Cooperband, the 1994 activities consisted of two phases: composting varying mixtures, and the nutrient release of these materials. The four MSW/poultry litter combinations were 21:1, 6:1, 3:1 and 1:1. MSW compost came from Ferst, Inc., which composts unsorted garbage from Baltimore. Poultry litter came from chicken houses in Queen Anne's county. Compost piles used a passive aeration windrow system.

Cooperband offers these conclusions: "It appears we can accelerate the composting of MSW by cocomposting with poultry litter. In terms of combinations for direct soil application, it appears we can modify both the magnitude and the pattern of soluble P released from organic wastes like poultry litter by combining with a high carbon material like MSW. When we consider that the time window of greatest crop demand for nutrients like N and P occurs between 25 to 75 days after seedling emergence, we realize that the temporal patterns of nutrients released from 6:1 to 1:1 MSW:poultry litter combinations coincides nicely with greatest crop utilization. The combination of urban and agricultural wastes holds promise as a slow release fertility source for agricultural use."

COMPOSTING AND SUSTAINABLE AGRICULTURE

Increasingly, the farm community and researchers are developing firmer links to the theory and practice of organics recycling. Information sources such as those provided by the Alternative Farming Systems Information Center at the National Agricultural Library in Beltsville, Maryland, under the direction of Jane Gates; the Sustainable Agriculture Network based at the University of Vermont; and the Henry A. Wallace Institute for Alternative Agriculture in Greenbelt, Maryland make the connection between composting and agroecology.

At Ohio State University, for example, Professor Harry Hoitink is leading a team of researchers showing the impact of compost on suppressing plant disease, thereby reducing the need for chemical pest control applications. The Sustainable Agriculture Program at Ohio State includes a four year project to examine the importance of earthworms as regulators of decomposed community structure, organic matter decomposition and nitrogen cycling based on organic or inorganic sources of nutrients.

AVOIDING PROBLEMS WITH NITRATE LEACHING

Research has shown that nitrate leaching occurs after excessive applications of inorganic fertilizers. Land spreading of organic wastes, such as manures and biosolids, has also resulted in nitrate leaching. Composting is one method of stabilizing manures by removing compounds such as ammonia leaving more stable organic forms that must be decomposed by soil microorganisms before they are available to crops.

A study by the Connecticut Agricultural Experiment Station conducted by Abigail Maynard focused on determining if composted animal manures could be applied yearly at rates high enough to supply all the nutrients in an intensive vegetable production system without contaminating the groundwater with nitrate. Yield data from these experiments suggest that composted animal manures can provide most, if not all, of the fertilizer requirement. The two composts used in the experiments were produced by Earthgro, Inc. Spent mushroom compost (SMC) consisted of horse manure and bedding amended with some chicken manure, gypsum, cottonseed meal, and cocoa bean shells. The mix had been composted outdoors for about six months in static piles turned monthly. Total nitrogen content was approximately 0.6 percent and the nitrate-N content was approximately 14 ppm. Chicken manure compost (CMC) a mixture of chicken manure (43 percent), horse manure (14 percent), spent mushroom compost (29 percent) and sawdust (14 percent) was composted for about 20 days in an in-vessel system utilizing forced air and an agitated bed. Total nitrogen content was approximately two percent and nitrate-N content approximately 54 ppm.

Results indicate that compost can be added for three consecutive years at rates high enough to supply most of the fertilizer requirements without excessively contaminating the groundwater with nitrate. The results also suggest a cumulative effect in the soil with yearly additions of compost with increases in nitrate in the groundwater approaching the limits of contamination after three years of application. In subsequent years, to lessen nitrate leaching, it appears that lower rates should be applied, especially with chicken manure compost.

MORE COMPOST, LESS CHEMICALS, MORE PROFITS

It took Ralph Jurgens almost 20 years to establish working relationships with 400 farmers who wanted to set up integrated biological systems on their acreage. Just in the past 12 months, his New Era Farm Service in Tulare, California has signed up another 100 growers. These 500 farmers represent over 500,000 acres of land that now receive annual applications of compost as part of an organic matter management system.

"Farmers are coming to us with questions about transitional and sustainable agricultural methods. They want to find out what to do so they can cut back on using pesticides, herbicides and chemical fertilizers," explains Jurgens. Compost is a key element in the transition process, and Jurgens, an agronomist, provides consulting services as well as the product. His firm makes 100,000 tons of compost a year 60,000 tons at its three sites mainly using dairy and steer manure as feedstock and another 40,000 tons at nine custom sites on large-scale farms using both manure and cotton gin trash. The compost sells for $17 per ton plus freight.

Typical of the farmers now using a biological approach is Jack Pandol, Jr. of Pandol and Sons, Inc., who last year became Undersecretary of California's Environmental Protection Agency. Pandol and Sons farms 6,000 acres of vegetables, tree fruits and grapes in the San Joaquin Valley. He began working with New Era four years ago, seeking to cut his pesticide use in half over a five year period. He actually achieved an 80 percent reduction in three years.

A major push for change in farming methods is coming from off the farm policies as well as on farm economics. Just as legislation such as disposal bans on yard trimmings led to thousands of composting programs, laws like the California

Clean Water Drinking Act are moving farmers away from excessive reliance on toxic pesticides. At the same time, high insurance premiums and costs of Workman's Compensation claims, as well as proposed bans on materials like methyl bromide, have become significant factors to get farmers to use Integrated Pest Management techniques. Increasingly, compost is recognized as vital in the economics of transition.

SUPPLIERS AND USERS

Within a 50 mile radius of New Era's headquarters in Tulare, there are 1,000 dairies, averaging over 1,000 milk cows, with each cow producing between four and five tons a year of dry manure. "Our challenge," says Jurgens, "is to collect and compost this manure economically. We can't be making a lot of products and then have them be too expensive for the end users, especially farmers who are usually strapped for money, and also hope to educate them in the process."

The education focuses on organic matter management, with an emphasis on growing green cover crops as part of the fuel for organic matter, and then using composted products as the microbial and biological stimulants. Not only is compost a humus product, but when made properly, it is also a microbial product that will actually inoculate the soils to further improve soil structure.

A typical scenario for cotton growers in the San Joaquin Valley, has been to apply 10 tons of raw manure per acre. Usually, that causes much rank growth as a result, and bolls do not properly mature. "By using three tons of compost per acre, we can get all the bolls to mature evenly and open up at the same time, enhancing production for less money," says Jurgen. On composted fields, growers saved $35 an acre in defoliation costs compared to uncomposted fields. Application rates are usually from two to four tons of compost per acre, depending on the specific farm and crop history.

Competitive tests evaluated the application of compost along with commercial fertilizer. Says Jurgens: "Properly made compost and composted products can enhance conventional cropping systems and conventional fertilizers, making them more efficient. Therefore, we can use less commercial fertilizer."

HIGH RISE MORTALITY COMPOSTING

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Disposal of dead birds on the poultry farm is a constant concern. Normal mortality must be dealt with on a daily basis. One of the easiest, environmentally friendly methods is composting. Most of the literature for design and protocol for dead bird composting pertains to broiler farms. These setups are designed with an outdoor bin system close to a good supply of dry poultry manure and use of a carbon source. i want to tell you about Glenwoods experience with in-house composting and the potential pit falls.

Our first system included construction of a three bin composter located in the pit front of each of two high rise houses. Each bin measured 4'x 4'x 4' and was constructed with pressure treated lumber. the front of each bin utilized removable 2"x 6"x 4' pressure treated lumber. In all aspects, it looked like a typical composter setup simply built inside on the existing concrete floor. Cost was minimal.

The mixture in the composter began with a layer of manure, then straw, then dead birds followed by manure again. This pattern was repeated until each bin sequentially was full with the last layer always being straw to avoid house fly activity. Turning of the mixture was intentionally not done. When the last bin was full, the first bin was emptied by hand into a wheelbarrow and distributed throughout the manure pit. Even though the composted material had not been turned, the temperature had reached 130 to 140 degrees and bird decomposition was fairly complete.

This process works well when the level of mortality remains consistent. Heavy mortality does not allow enough time for good decomposition to occur. Also water must be added if the manure layers are not moist enough; however, too much water will cause birds to rot instead. if the material is removed before proper composting has time to occur, body parts may be visible. This can allow house fly breeding to occur in the carcasses.

Glenwood Farms used this disposal method on our contract farm for 10 months. The farm had 2 - 115,000 bird high rise houses with an average mortality of 150-200 birds per house per week. This mortality level can become unmanageable and the composting system may fail if daily attention is not administered. Therefore, we experimented with direct manure composting.

For a period of 8 months, daily mortality was placed directly on the manure piles in the pit. Dead birds were dropped into a wheelbarrow and distributed throughout the house. The birds were laid side by side in a single layer on the peak of the manure pile. Birds were covered with a 1" layer of manure to discourage house fly activity. One entire row was completed before beginning another to allow additional manure coverage from the birds upstairs.

This system is simple to initiate, requires no carbon source and can handle any amount of mortality. there is also no detectable odor. Bird decomposition was thorough if the manure was not disturbed for 5-6 months prior to cleanout. The biggest advantage is that each house handles only its own mortality. There is no need for a separate building or equipment to turn or move the compost.

With all this going for it you would think we would be still using this method. However, today Glenwood Farms has all its mortality picked up in drums by a renderer two times per week. We learned the hard way the negative aspects when it came time to clean out the house.

At this time, we discovered that bird decomposition was not as thorough without turning the mixture or use of a carbon source if the manure is removed to soon. If time allowed for true composting is not sufficient then complete decomposition does not occur. Both of the a forementioned disposal methods have their place in the poultry industry if proper precautions are taken. However, the consequences if mistakes are made can be costly.

USE OF POULTRY MANURES ON CITRUS AND PINE TREES

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Florida is a rapidly urbanizing state with a very sensitive environmental balance. Poultry production has either been static (in the case of laying hens at approximately 10-12 million hens) or growing (broilers) at the rate of three to five percent annually. There is no commercial turkey industry within the state.

Traditionally, poultry manure has been applied on pasture lands and on home farming operations. The advent of larger layer complexes, increased localized broiler density and rapid urbanization have greatly restricted these historic uses of poultry manure. The need exists for large tracts of land located somewhat distant from significant population centers. Two viable alternatives exist. Extensive pine tree plantations exist in North Florida and citrus groves are numerous in Central and South Florida. More data is needed to increase manure utilization in these areas.

CITRUS PRODUCITON

Poultry manure is utilized in citrus production to augment or replace standard granular fertilizers from strictly a cost standpoint or to produce "certified organic citrus". This organic citrus accounts for only 1 percent of production with approximately 80 percent of these producers citing chicken manure as the preferred fertilizer source. The market for organic citrus is growing and will be accompanied by increased demand for poultry manure.

Action Taken

Fresh and processed chicken manure were applied to bearing and non-bearing trees in Central and South Florida. Fresh manure was applied to 3-year old trees at the rate of 10 tons per acre per year (280-330 lbs of nitrogen) and 20 tons per acre per year (560-660) lbs of nitrogen). Processed chicken manure and granular fertilizer were applied at recommended rates on immature orange and grapefruit stock and growth measurements recorded.

Results

There were no significant differences in tree growth or fruit production between the 10 and 20 ton application rates of fresh manure. Over the two year experiment, tree growth averaged a 1 inch increase in trunk caliper and three feet in tree height. Yield on young trees and mature naval oranges showed no significant differences due to application rate. No symptoms of leaf burn or fruit damage were observed due to application of fresh manure. Processed chicken manure and granular fertilizer stimulated comparable growth in stem caliper and plant height in both orange and grapefruit studies.

PINE TREES

Pine trees are utilized for wood production and fallen needles are popular as pine straw mulch. However, removal of the needles removes a primary nutrient source for wood production and additional needle growth. Fertilization has been shown to increase wood production in pines but careful economic analysis is lacking. The application of fertilizers or manures may be difficult or require specialized equipment due to rough terrain or tree spacing. Nutrient application prior to establishment or replanting pine plantations is a less difficult task. The use of locally produced poultry manure may be an economically feasible method of pine tree fertilization. However, other concerns, such as a possible increase in fusiform rust and pitch cancer have made forest managers reluctant to apply manure to pines.

Action Taken

A field demonstration was initiated using a nine-year old slash pine stand. There were 7 treatments with 3 replications per treatment. Each plot was approximately 1/4 acre in size.

Areas to be measured were wood production, needle production, disease incidence and ground water nitrogen sources, phosphorus and copper.

Treatments were:

1) Control (no fertilizer applied).
2) Broiler litter application at experiment initiation only.
3) Broiler litter application at experiment initiation and during year 2.
4) A layer manure slurry application at experiment initiation only.
5) A layer manure slurry application at experiment application and during year 2.
6) Commercial fertilizer application at experiment initiation only.
7) Commercial fertilizer application at experiment initiation and during year 2.

Fertilizer sources were adjusted to provide 250 pounds of available nitrogen per acre the year of application. Studies with tree growth are long term and these data are still preliminary. Water samples were taken from shallow wells (4-feet) monthly and similar results have been noted for manure treated and commercial fertilizer treated plots.

EXPERT SYSTEMS FOR POULTRY MANURE MANAGEMENT[1]

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Manure management is complex for most people managing poultry production facilities. The number of details that need to be considered seems almost endless. Like a number of other parts of our enterprises, manure management could be made easier if we had an expert available who was willing to sit quietly and answer our questions and carefully remember the answers so they could make some of those tedious calculations that the Extension Service says are necessary to apply manure to cropland. An expert system is one of the alternatives available to try and provide that kind of service. Most people will agree that a computerized expert system is inferior to actually having your own personal expert close at hand, but, it is also far less expensive and may solve some of the issues that would otherwise send you off to your expert.

Perhaps an example is the best way to explore how an expert system operates and whether one can be useful to you. The program we will explore together was devised to help decide how available livestock or poultry manure can best be applied to cropland to obtain the maximum possible economic benefit while protecting the surface and groundwater quality of the area. This program organizes the information needed to make this decision, performs the calculations, and remembers the results so the analysis can be completed without unusual pain or suffering. The program was kept as general as possible so the user could enter specific information and anticipate the recommendations to be unique to his/her enterprise and to the inputs made.

The program is based upon the INTeractive PROgram development system (INTPRO) distributed by the University of Florida. The entire program and all of the software needed to run it are contained on a single disk. The user is invited to view this software as a visit to an expert being paid to provide

[1]Technical Paper No. 10,957 Oregon Agricultural Experiment Station, Corvallis, OR 97331.

professional advice. The expert will listen carefully to the answers and will provide his most highly considered judgement. The user is, of course, free to ask that another situation be considered.

BACKGROUND

The application of manure to cropland is both an economic and environmentally significant decision. Properly managed and applied to cropland, manure is a valuable resource that can replace chemical fertilizer that would otherwise need to be purchased to obtain appropriate yields for an economically viable enterprise. Under many situations, research data indicate animal manures to have properties that provide benefits not available from using chemical fertilizers. Alternately, however, irresponsibly managed or applied in amounts that exceed the capability of the crop to utilize the nutrients, manure application can contribute to surface water pollution and to groundwater contamination. Under application of manure results in less than optimal crop yields.

Determining the most appropriate manure application rate can involve a relatively complex set of calculations based on the nutrient content of the manure, the nutrient status of the soil, the projected nutrient utilization of the crop, and nutrient losses anticipated in the system. This program was designed to facilitate that set of calculations and provide the livestock/poultry producer a convenient way to plan his/her manure disposal. Provisions are also included to incorporate any regulatory limitations into the application calculations.

Intended Users

This program is intended to serve the needs of livestock and poultry producers under two specific situations. First as a planning aid: as plans are being made to establish or expand an enterprise, the program will help estimate the land area needed for manure disposal based on the animal numbers, manure management scheme, anticipated crops, and regulatory constraints. Secondly, the program will accept results of manure analyses to calculate a specific application rate and a land area to which the manure can be applied.

The program assumes no particular computer skills on the part of the operator. The initiation of the program is with the typing of a single line. Thereafter, user instructions appear on the screen at all times. In addition, the user has the option of moving backwards in the program if at any point it is necessary to change an answer or to see what would happen if an alternate answer had been given.

What to Expect

The user should regard this program as an expert engaged for advice on manure application rates. It offers the choice of using any analytical data available or it will allow entering information as to the species of animals raised in confinement, the number of animals, their average weight and certain features of the manure management system. At several points it will ask the user to indicate nutrient losses in certain operations. Each time information of this type is requested, "Help Screens" are provided showing the typical range of values for various systems. The user has the opportunity to select the description most like his and then to pick the value which best describes his particular system.

Toward the end of the program, it will request the nitrogen and/or phosphorus application rate to be used as a basis for land application. That rate may be based on a soil analysis and the recommendation of an agronomist or it may be based on regional agronomic recommendations. It may also be based on application constraints set by local or regional pollution control authorities. The better that value, the more reliable will be the recommendations from the program. Remember, the output from a program of this type can be no better than the input numbers.

HARDWARE REQUIREMENTS

This program was designed for use on IBM PC compatible microcomputers with IBM or Microsoft DOS(disk operating system) version 3.0 or higher. It is sufficient to have at least 360 kilobytes of free random access memory (RAM). A computer with a CGA or EGA graphics system is preferred in order to utilize the full color capabilities of the program.

GETTING STARTED

No installation is required in order to run this program on an IBM compatible microcomputer with the necessary adapter cards and video display monitor. To start the program, insert the disk provided in drive A or B and make that drive the current drive. For example if you placed the provided disk in drive A, Enter **A:** then, enter **INTPRO MANURE.** After a slight delay, to load the program, the program will start. The first screen to be displayed is the INTPRO banner screen.

There are three ways to stop the program. One way is to run the program to its conclusion, at which time it will stop execution and return to DOS. Another method to stop the program at any time is to Press **ALT-F10**. The third method is to Press **Esc.** Either the Alt-F10 keystroke combination or Escape allows a user to exit the program from any screen. The user has the option at any time to return to the beginning of the program by pressing F9.

INTRODUCTION TO THE USER INTERFACE

The INTPRO software allows three types of screens. Each of these has three segments as follows:

Title window
: The upper three lines of the screen will display a title as black text on a white background.

Interaction window
: Immediately below the title is the interaction window which contains the main business of the screen. Information may be presented, a choice between options requested, or a specific input such as the number of animals in the system or the nitrogen application rate as suggested by a recent soil analysis may be requested.

Help window
: The help window contains two lines which remind the user of available help. The F1 function key is used to call help which is specific to the screen being displayed. The F2 function key is used to call a screen listing how the special keys are used in the program.

Information Screens

Information screens are provided in the program to provide information to the user. This may be general background that is instructive or in other cases may present the results of calculations based on previous input data. No particular response is required except to indicate when the user is ready to move on to the next screen. Many people prefer to use the space bar as their signal but any key will serve.

Choice Screens

Choice screens are used throughout the program when information is needed from the user. Choice screens will generally contain a question in the upper part of the interaction window and two or more alternative answers immediately below. One of the alternative answers will be highlighted. The user is to move the highlight to the proper alternative by pressing the curser up key or the curser down key to the desired alternative then, pressing the Enter or Return key to record the response.

Numeric Screens

Immediately below the title block of a numeric screen there is a question or instructions and below that, one or more prompts. Following each prompt is space for an answer. The curser will highlight one of the answer spaces. Immediately to the left of the highlight, enclosed in square brackets, will be a default value. If the user agrees with the value in the highlighted area, they may Press Enter and the curser will move to the next blank. If not, they enter their value then Press Enter. Numbers can be erased using the Backspace key. After the final number has been entered, the program will move forward.

Many of the numeric questions have been provided a range of acceptable values. If the user enters a number outside this range, they will see the message, "Your response of _____ is not within the acceptable range of __ to ____. At this point, the user should reconsider and enter a new response within the acceptable range.

SAMPLE RUN

As an example of how the program operates, let us assume that you are the operator of a 100,000 head layer operation, have a lagoon and that you had a sample of that lagoon water analyzed. The analyses has been returned to you and you want to apply the liquid from the lagoon to a Bahiagrass field. You have estimated that you have 2.4 million gallons of the material available for application during the coming season.

Analysis of lagoon sample	
Total solids	760 mg/l
Total nitrogen	360 mg/l
Phosphorus as P	68 mg/l
Potassium as K	47 mg/l
pH	7.4

You want to know how much you should apply per acre and how many acres you will need to spread it over. You have had a soil analysis conducted and it was recommended that you apply 400 pounds of N per year, 100 pounds after each cutting, that you apply 60 pounds per year of phosphorus as P_2O_5 and no potassium.

1. Initiate the program by inserting the disk in Drive A of your IBM compatible microcomputer and establish Drive A as the operating drive.

2. Enter INTPRO MANURE

3. The INTPRO banner should appear for a few seconds followed by the first information screen which explains the purpose of this program.

4. Press F1 if you want to know additional information about the program or its developers, otherwise, press the space bar.

5. Proceeding in this manner, you will view two more information screens and then will be presented a Choice Screen that asks if you have data available. Three options are given:

   Data available; N, P and K concentrations and quantities.
   Data available; N, P and K concentrations but no quantities.
   No data available regarding concentrations or quantities.

   Using the curser control keys, move the highlight to the first option, if it is not already there, and press Enter.

6. Another choice screen appears asking, in what units your analyses are available.

   mg/l or parts per million
   pounds per acre foot
   pounds per thousand gallons
   pounds per ton

   Using the curser control keys, move the highlight to the first option, mg/l, if it is not already there, and press Enter.

7. The next screen will ask you to enter your analyses in "mg/l or parts per million since that is the set of units you selected. Alternatively, another set of units would have been requested if that is what you selected.

Nitrogen incl. ammonia	[0]	____
Phosphorus as P	[0]	____
or Phosphorus as P_2O_5	[0]	____
Potassium as K	[0]	____
or Potassium as K_2O	[0]	____

   With the curser highlighting the space for a nitrogen concentration, enter your value (360). Press Enter to move the curser to the next data entry point, enter the P concentration (68), press enter twice to move the highlight to the potassium as K line and enter 47.

   Had your values for phosphorous been given as P_2O_5. You would have moved the curser to the "as P2O5" line and entered the value. Similarly, with the potassium concentration. Review your entries and use the curser control keys to position the curser so you can correct any errors. Press Enter to move on to the next screen.

8. The next screen will ask you to select how you want to input your quantity data. Select from among the options (millions of gallons per year). Move the highlight to this line and press Enter.

9. The next screen will ask you to enter the quantity of material you have available in the units you selected, millions of gallons per day. Enter 2.4, review your entry, and if everything is correct, press Enter.

10. After a brief period of a blank screen, the next screen will summarize the input you have provided. After you assure yourself it is accurate, press Enter and you will see a screen that presents the total quantity of N, P, and K available to you.

11. At this point, you are entering the land application segment of the program. Two information screens are available to help you decide whether you want to have the program base its calculations on nitrogen or phosphorus or on a complete nutrient recommendation. The next screen will let you choose between those three. Since you have a complete recommendation, that is the choice you will want to make.

12. You will be asked to estimate how much nitrogen will be lost due to ammonia volatilization during the application process. A "Help Screen" is available. A value of 25% is typical for lagoon water applied using sprinkler irrigation equipment. Enter the value of 25 in the highlighted area then press Enter.

13. The next screen will respond to your input by summarizing how much nitrogen was lost due to volatilization and how much is left for crop use.

14. Since you indicated you had a complete fertilization recommendation, you will be asked to enter that information in the next screen. Please enter this information for N, P, and K as the individual nutrients are highlighted. In this example, you will enter 400 for Nitrogen, 60 for P as P_2O_5, and 0 for potassium.

15. The next two screens will provide you recommendations based on the nitrogen and phosphorus application rates you selected. You will see how many acres can be fertilized

using either as the basis and in each case know the resulting application rate of the other two nutrients.

```
Land area based on a complete fertilizer recommendation
-------------------------------------------------------------
You indicated a fertilizer recommendation as follows:

   Nitrogen:      400 Lb./ Acre
   Phosphorus:     60 Lb./ Acre expressed as P2O5
   Potassium:       0 Lb./ Acre expressed as K2O

By using the nitrogen application rate,

   Land used for manure application: 13 Acres
   Nitrogen application rate:  400 Lb./ Acre
   Phosphorus application rate: 238 Lb./ Acre
             expressed as the oxide, P2O5
   Potassium application rate: 87 Lb./ Acre
             expressed as the oxide, K2O
-------------------------------------------------------------
Press any key to continue
```

```
Land area required for manure application based on a complete
fertilizer recommendation.
-------------------------------------------------------------
By using the phosphorus application rate,

   Land used for manure application: 52 Acres
   Nitrogen application rate: 105 Lb./ Acre
   Phosphorus application rate:  60 Lb./ Acre
             expressed as the oxide, P2O5
   Potassium application rate: 22 Lb./ Acre
             expressed as the oxide, K2O
      Note! Although this strategy makes the maximum use
          of the available phosphorus, it may require
          that supplemental nitrogen and possibly
          potassium be added to supply the recommended
          quantity of those nutrients.
```

---

16. If you press the space bar at this point, you will return to the disk operating system.

    Suggestion!! if you press F9 and repeat the process but select the option based on concentration data only being available, input only the quality data, the program will calculate how much of the lagoon water you should apply to the fields to achieve the desired nutrient application rates. You will find that you will need to apply a total of 6 inches over the year.

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GRASS STRAW OR OTHER ALTERNATIVES AS POULTRY LITTER

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In the United States, commercial broiler chickens are raised virtually exclusively on the floor using some form of bedding (litter after it is used). The bedding is used to keep the birds from direct contact with the flooring, to insulate the birds from the cold ground or floor, especially when they are young, and to absorb moisture from the bird's droppings or spillage from drinkers. Because of the relatively high stocking density in modern broiler management, the bedding plays an important role in the overall production scheme. If improper materials are used, reduced productivity, increased mortality, and/or reduced carcass grade can result yielding reduced profitability for the grower and integrator alike.

For the most part, broiler growers prefer to use a material that is free, highly absorbent, never cakes with manure, and can be sold as a premium product after the birds are marketed. While the above scenario may not be possible, there is a continual search in that direction.

Traditional bedding materials are usually another industry's by-products. Therefore, bedding materials differ regionally depending on local industry and agricultural production. In most areas of the country, wood shavings or coarse sawdust are the most common bedding types. However, regional materials such as ground corn cobs, rice hulls, peat moss, peanut hulls, and many other agricultural by-products have been used successfully.

In recent years, non-traditional bedding materials, not necessarily from other segments of agriculture, have been tested for use by the broiler industry with mixed results. Such materials as, recycled paper products, ground polystyrene, shredded newspaper, and recycled sheet rock (dry wall) have been used. While each of these bedding materials has proven to be relatively successful, many growers return to the traditional wood shavings or sawdust.

In the Pacific Northwest, broiler producers have relied almost exclusively on wood shavings or sawdust for their bedding needs. However, their uses of these products have been impacted by several events in recent years. First, technological advances in the wood products industry have seen a great deal of sawdust and wood shavings funneled into the value-added stream, becoming among other products, particle board and oriented strand board (OSB), for the construction industry. These companies have been buying much of these by-products, thereby reducing their availability as broiler bedding and increasing their cost.

Second, environmental regulations have reduced the number of trees that are cut in Northwest forests. For many years, the forest industry in the Northwest has relied on the cutting of old-growth trees. However, pressure from environmentalists have slowed the flow of old-growth timber into mills which has reduced the amount of wood shavings and sawdust that is available. In addition, the cutting of second growth timber has also declined in environmentally sensitive areas.

Therefore, both technology and environmentalists, have forced broiler growers to seek alternative bedding sources. it is somewhat ironic that environmentalists, a large part of the reason that alternatives are necessary, also helped to provide part of the answer, at least in Oregon.

GRASS SEED STRAW

Farmers in Willamette Valley of Western Oregon provide much of the grass seed used to landscape homes, parks, and golf courses around the country. In the past, to improve production and reduce diseases, grass seed producers burned the residual straw and stubble in the fields. This practice created smokey conditions in the valley during late summer and fall each year, which aggravated health conditions of many of Oregon's citizens. In the late 1980's, field burning was determined to be a negative agriculture practice and began to be phased out by legislative action. The result was that grass seed producers began baling the straw that previously had been burned. As the phase-out of field burning continued, the bales were piling up.

Today, approximately 100 million kilograms of grass seed straw is produced in the Willamette Valley annually. Some of this product is exported, some is recycled into other end-user products, some remains stacked in fields, unused.

Early work with grass straw at Oregon State University (Nakaue and Hermes, 1995) showed that grass straw could be used successfully as broiler bedding (Table 1). These experiments were carried out in small pens, approximately 100 broilers per pen, in replicate treatments. Little difference in final body weight, feed conversion, mortality, or litter caking was noted.

TABLE 1. Seven-week performance data of commercial broilers reared on sawdust, chopped annual rye, rye, orchard grass, fescue, and pelleted rye grass straw litter

Litter Material	Mean Body Weights (g) Males (M)	Females (F)	M + F	Feed Conv. Ratio	Mort. (%)
Sawdust	2477[a]	2068[ab]	2263[a]	2.14[a]	2.5[a]
Chopped annual rye grass straw (~5.1 cm long)	2572[a]	2023[a]	2277[a]	2.15[a]	1.7[a]
Chopped perennial rye grass straw (~5.1 cm long)	2499[a]	2118[ab]	2313[ab]	2.13[a]	1.1[a]
Chopped fescue straw (~5.1 cm long)	2522[a]	2037[a]	2286[ab]	2.13[a]	1.1[a]
Chopped orchard grass straw (~5.1 cm long)	2499[a]	2037[a]	2354[b]	2.15[a]	2.2[a]
Pelleted rye grass straw (.32 cm dia)	2585[a]	2136[b]	2354[b]	2.15[a]	2.2[a]
Pooled SEM	36	28	25	.01	.7

[a,b]Values columns with different superscripts are significantly different at $P<0.05$.

Upon completion of the controlled experiments, we tested chopped grass straw bedding under commercial conditions. Mr. Bernie Gamble, Junction City, Oregon, along with his integrator, Fircrest Farms, Creswell, Oregon, made a portion of his broiler farm available for testing of grass straw bedding.

Two identical broiler houses (12.1 m x 92.7 m) were identified for use in the four batches (September through May) in this study. Both houses were mechanically ventilated and insulated. Feed was delivered via pan type feeders and drinkers were eight foot troughs. Approximately 15,500 chicks were placed in each house during each batch. Cake was removed and the used litter was rototilled between batches. market age varied between 41 and 47 days of age.

In one house, 2 units (13.7 m^3) of wood sawdust were added on used sawdust litter yielding a clean layer of about 1 cm. In the other house, between 365 kg and 455 kg (10 bales) of grass straw was added over used sawdust litter, giving a depth of between 1 and 2 cm. From the original work at Oregon State University, chopping the grass straw was determined to be necessary for best results. The bales were chopped, to lengths between 2.5 and 5 cm, using a bale chopper attached to the three-point hitch of a tractor. Litter management was similar for each batch.

Throughout the four batches, production results and energy usage varied (Tables 2 and 3), partly due to market age, but showed no consistent trends to preclude grass straw as a viable alternative to sawdust for broiler bedding. the birds performed equally well and used similar amounts of utilities when housed on chopped grass straw compared to sawdust.

TABLE 2. Average performance of broilers during four batches using sawdust or chopped straw bedding under commercial conditions

Litter Type	Market Age	7 Wk Body Wt. (kg)	Mort. (%)	Feed. Conv. Ratio	Carcass Grade A (%)	Condem. (%)
Sawdust	44	2.33	5.03	1.94	59	1.18
Chopped Grass Straw	43	2.22	5.53	1.84	75	1.43

TABLE 3. Average utility usage and water consumption of broilers during four batches using sawdust or chopped grass straw bedding under commercial conditions

Litter Type	Electric Usage (kwh)	Propane Usage (gal)	Water Consumption (gal)
Sawdust	1,323	394	28,998
Chopped Grass Straw	1,687	393	27,718

When the economics of grass straw and sawdust as bedding are compared (Table 4), broiler producers can realize substantial savings when using grass straw.

TABLE 4. The economics of grass seed straw vs. sawdust

Litter Type	Amount per Batch	Cost per Unit	Cost per Batch	Cost per Year
Sawdust	2 Units ($13.7\ m^3$)	$65	$130	$780
Chopped Grass Straw	10 Bales (455 kg)	$1.50	$15	$90
		Savings by using Grass Straw	$115	$690

PAPER MILL WASTE SHORT FIBER

Washington state broiler producers are experiencing similar shortage of traditional bedding materials. Sawdust and wood shavings, which have been by far the most common material used for broiler bedding, have become more difficult and expensive to obtain. The reasons here are similar to Oregon's shortage but the effect is not yet as severe. Washington does not have a large grass seed industry so other alternatives are needed.

In the last decade or more, recycling has become common place. Paper and paper products may be the most commonly recycled products. However, even when recycling, some loss is realized in the remanufacturing process. The same is true in the manufacture of virgin paper. This waste product is in the form of short fiber.

Short fiber is that portion of the cellulose fibers that are too short to be utilized properly in paper manufacturing or recycling. These fibers are traditionally disposed of in landfills. With increased landfill tipping rates, reduced availability, and increased cost of wood by-products, waste short fiber was considered a possible alternative bedding for broilers. The processes developed by Absorption Corp. (patents 5,358,607 and 5,091,245) have been used for several years to manufacture pet bedding while just recently commercial broiler bedding was considered.

Two trials were performed comparing both virgin and recycled short fiber waste (donated by Absorption Corp.) to the more traditional bedding materials, wood shavings and chopped grass straw. In the first trail, 7 to 10 cm deep bedding materials were placed on concrete floors in small pens while during the second, about 5 cm was place over used litter of the same type, after the cake had been removed. One hundred and fourteen birds were placed in each pen at a density of 0.065

m^2 per bird. Three replicate treatments were raised on each litter type.

Heat was provided by heat lamps, feed and water was given ad libitum. Mortality was recorded daily, litter caking scores were taken weekly beginning with the second week, body weight and feed consumption were determined at four and seven weeks. Subjective litter caking scores were, 1 for 1/4 of pen caked to 4 for the entire pen caked.

The first trial, the birds performed equally well on the short fiber as the traditional bedding (Table 5). When examined separately, there was no difference noted in the level of litter caking between the bedding types; however, when the traditional types (sawdust and grass straw) were compared to the short fiber (virgin and recycled), the short fiber bedding was less caked (P<.05) and 2 and 4 weeks (Table 6). Similar production results were obtained in the second trial (Table 7); however due to weather conditions, all production traits were poorer in the second trial. Litter caking was similar for all bedding types.

TABLE 5. Seven week performance of broilers raised on various clean bedding materials

Bedding Type	Av. Body Wt. (g)	Feed Conversion Ratio	Mortality (%)
Sawdust	2547	2.00	7.31
Chopped Grass Straw	2511	1.99	4.97
Virgin Short Fiber	2492	2.02	4.97
Recycled Short Fiber	2542	2.04	6.73

TABLE 6. Average weekly litter scores from broilers raised on various clean bedding types

Bedding Type	Weeks of age					
	2	3	4	5	6	7
Sawdust	0.40	1.12	1.52	2.53	2.83	3.22
Chopped Grass Straw	0.52	1.29	1.69	2.76	3.12	3.47
Virgin Short Fiber	0.21	0.96	1.35	2.61	3.04	3.52
Recycled Short Fiber	0.25	1.02	1.31	2.57	2.90	3.46
Sawdust + Grass Straw	0.46[a]	1.25[a]	1.61[a]	2.65[a]	2.97[a]	3.34[a]
Virgin + Short Fiber	0.23[b]	0.99[a]	1.33[b]	2.58[a]	2.97[a]	3.49[a]

[a,b]Different letters in columns denote significant differences ($P<0.05$).

TABLE 7. Seven week performance of broilers raised on various built-up bedding materials.

Bedding Types	Av. Body Wt.	Feed Conversion	Mortality (%)
Sawdust	2107	2.20	7.31
Chopped Grass Straw	2048	2.25	10.82
Virgin Short Fiber	2093	2.29	6.73
Recycled Short Fiber	2043	2.26	6.43

No significant differences.

From this study paper mill waste short fiber materials appear to be adequate as broiler bedding. A small industry trial was done and these materials were found to be adequate under industry conditions.

The economic benefit of short fiber bedding materials are not as promising as grass straw, partly because large scale production of these products is yet to be accomplished. Currently, the cost is relatively high; however, as traditional sources of bedding become less available and more expensive, this product may provide an adequate alternative.

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STATE OF THE ART IN AMMONIA AND PHOSPHORUS ISSUES

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The objective of this paper is to give a brief overview of the problems associated with ammonia volatilization and non-point source phosphorus runoff and to outline potential solutions to these problems. For more comprehensive reviews in this area, see Edwards and Daniel (1992), Moore et al. (1995a), and Sims and Wolf (1994).

PROBLEMS CAUSED BY AMMONIA VOLATILIZATION

The dominant form of inorganic N in manure is ammonium (NH_4). Ammonium is converted to ammonia (NH_3) as pH increases. Ammonia (NH_3^o) is in equilibrium with NH_3(g) (ammonia gas), which diffuses from the litter into the atmosphere. This process is referred to as ammonia volatilization and can lead to very high levels of ammonia in poultry houses, as well as cause atmospheric ammonia pollution. Anthropogenic ammonia emissions in the U.S. were approximately 840,000 tons/year in 1980, with 64% (540,000 tons) associated with livestock waste management (U.S. EPA, 1987).

Ammonia volatilization from poultry litter causes several problems, including; (1) decreased poultry performance, (2) health risks to farm workers, (3) air pollution, and (4) lowered fertilizer value of litter due to N loss.

Effects of Ammonia on Poultry Production

High ammonia levels have been shown to cause decreased growth rates (Reece et al, 1980), decreased egg production (Deaton et al, 1984), reduced feed efficiency (Caveny et al, 1981), damage to the respiratory tract (Anderson et al., 1964), increased susceptibility to respiratory diseases, such as Newcastle disease (Anderson et al., 1964), increased incidence of airsaculitis (Kling and Quarles, 1974), and increased incidence of blindness in poultry (Bullis et al., 1950).

Health Risks Posed by Ammonia

Chronic exposure to ammonia can cause serious health problems in humans (U.S. EPA, 1981). In Europe, an eight hour exposure limit of 25 ppm has been set by COSSH (Control of Substances Hazardous to Health), with 35 ppm for a 10 minute exposure (Williams, 1992). These values are regularly exceeded in poultry houses, particularly in winter months when ammonia levels of 50-100 ppm are common.

Effects of Ammonia on Air Pollution

The primary concern in Europe from atmospheric ammonia is acid rain (Ap Simon et al., 1987). Van Breemen et al. (1982) found that when ammonia is adsorbed into rainwater, it initially increases the pH. This increase in pH increases the amount of SO_2 that will dissolve in water. Ammonium sulfate forms and when it reaches the soil, the NH_4-N is oxidized to NO_3-N by microorganisms, releasing nitric and sulfuric acid. The dominant source of ammonia in Europe is livestock wastes, with long term trends showing a 50% increase in ammonia emissions from 1950 to 1980 (Ap Simon et al., 1987). As a result of acid rain from ammonia, the Dutch Government has implemented a plan to reduce ammonia emissions from manure by 90% relative to the levels released in 1980.

Atmospheric ammonia deposition can also contribute to eutrophication. Atmospheric N loading tripled in Denmark from 1955 to 1980 and corresponded to N losses from agriculture during this period (Schroder, 1985). The rising levels of N in the fallout were also shown to be correlated to the nitrate content in streams. Another aspect of air pollution related to ammonia is particulate matter less than 10 microns in size (PM-10). One of the sources of PM-10s is ammonium nitrate, which forms when atmospheric ammonia reacts with NO_x. Since animal manures represent the dominant source of ammonia in the atmosphere, ammonia fluxes from animal rearing facilities have received increased attention, particularly in California.

Effects of Ammonia Volatilization on Nitrogen Loss from Litter

The N content of poultry litter is lowered when ammonia is lost via volatilization. This not only results in a reduction of the fertilizer value of litter, it reduces the N to phosphorus (N:P) ratio in litter. The N:P ratio in poultry litter is normally around 2 or lower. Crops, on the other hand, need about 8 times more N than P. When litter with a low N:P ratio is used as fertilizer, the plants can utilize most of the plant available N, but not the P. The net result of this process is a large surplus of P in the soil, which can lead to increased P runoff and P leaching into groundwater.

PROBLEMS CAUSED BY NON-POINT SOURCE PHOSPHORUS POLLUTION

Effect of Phosphorus on Surface Water Quality

The U.S. EPA (1994) has estimated that non-point source runoff from agricultural lands is responsible for the water quality problems in over 70% of the lakes and rivers in this country. Phosphorus is considered to be the primary element of concern with respect to eutrophication of freshwater systems (Schindler, 1978). Eutrophication describes a condition involving excess algal growth, which may eventually lead to severe deterioration of the body of water. In Arkansas, the Department of Pollution Control and Ecology (DPC&E) has set guidelines on P in surface waters of 0.05 mg L^{-1} for streams and 0.10 mg L^{-1} for lakes and reservoirs. Recent research has shown extremely high P concentrations in the runoff water from pastures receiving low to moderate levels of poultry litter (Edwards and Daniel, 1992). The majority (80-90%) of the P in the runoff water is water soluble, which is the form that is most readily available for algal uptake.

Phosphate Buildup in Soils

Another problem in areas where there are high numbers of confined animal operations is that the concentration of P in the soils has surpassed the level needed for maximum crop growth and entered the range considered excessive. Kingery et al. (1994) observed soil test P levels as high as 225 mg P/kg soil in the soils in the Sand Mountain area of Alabama that had received long term applications of poultry litter. Since P concentrations in runoff water from agricultural fields are correlated to soil test P levels (Pote et al., 1996), the "background" levels of P in runoff water are high.

Phosphate Leaching to Groundwater

When soils are fertilized with large quantities of P, the P adsorption capacity of the soils becomes saturated and P begins to leach downward into the groundwater. This is a common occurrence in Holland, where high rates of manure have been applied for many years. Breeuwsma and Reijerink (1992) stated that leaching of P from soil has the major features needed to be described as a "chemical time bomb" (i.e. - there is a significant time delay between high application rates of P and adverse environmental impacts). The adverse impact is eutrophication of surface water, since they would have high P loading from both surface runoff and groundwater recharge. Breeuwsma and Reijerink (1992) indicated that in one catchment area in Holland the P loads to surface water were sufficient to achieve a mean annual P concentration of 1 mg P/L; 87% of which they attributed to leaching and groundwater recharge.

BEST MANAGEMENT PRACTICES FOR REDUCING AMMONIA VOLATILIZATION

Ventilation to Control Ammonia

Some poultry growers argue that increased ventilation will solve most of the problems associated with ammonia volatilization. This is somewhat true, however, ventilation in the winter is an expensive solution, due to increased energy costs. It should also be noted that while increased ventilation may improve the ammonia levels in the houses, it would contribute more ammonia to the atmosphere.

Chemical Amendments to Control Ammonia

Carlile (1984) stated that 25 ppm should not be exceeded in poultry houses for normal poultry production. Since the 1950's many different chemicals have been tested for their effectiveness to inhibit ammonia release from litter. Moore et al. (1995b, 1996) tested the efficacy of a variety of chemical amendments to reduce ammonia volatilization from litter in laboratory studies. We found that alum and phosphoric acid were the most effective compounds in reducing ammonia volatilization. Although phosphoric acid is very effective at reducing ammonia losses, it increases P solubility in litter by an order of magnitude, which would greatly increase P runoff problems. Therefore, it should not be used in areas containing P sensitive watersheds. Surprisingly, phosphoric acid is one of the primary litter treatments being used to control ammonia in Delmarva, which is situated in the Chesapeake Bay area.

Moore et al. (1995b, 1996) also found that treatments resulting in lower ammonia volatilization had higher N contents, as would be expected. Shreve et al. (1995) found tall fescue yields were significantly higher when fertilized with alum-treated broiler litter, compared to normal litter or litter treated with ferrous sulfate. The fescue fertilized with alum-treated litter was also found to have higher N contents than the other plants.

Recently, a commercial evaluation of alum treatment of poultry litter was completed (Moore et al., 1995c). This study was conducted on two broiler farms in Northwest Arkansas; one of the farms had six houses, the other four. Two tons of alum was applied per house in half of the houses on each farm, following each growout, for a full cycle (one year). Ammonia levels were significantly lower in the alum-treated houses than the controls, which was due to a decrease in litter pH. The improved environment associated with alum resulted in significant increases in weight gains (Moore et al., 1995c). Energy (propane and electricity) use was also lower in the alum-treated houses, due to lower ventilation in the winter.

BEST MANAGEMENT PRACTICES FOR REDUCING PHOSPHORUS RUNOFF

Phosphorus runoff from manure may be reduced by using BMPs such as: (1) proper nutrient management, (2) basing manure application rates on P, rather than N (3) utilizing buffer strips, (4) adding phytase enzymes to feed to reduce inorganic P requirements, and (5) aluminum sulfate additions to litter.

Nutrient Management Plans

One of the primary factors affecting P runoff from fields fertilized with poultry litter is the rate of application; with higher rates resulting in higher concentrations of P in the runoff water (Edwards and Daniel, 1992). Growers should calculate the nutrient requirements needed for maximum (realistic) crop yields, taking into account the N present in the litter, and apply the litter based on the amount of N needed by the crop and no more.

Phosphorus-based Manure Management Strategies

Manure applications are usually based on the N requirements of crops. Currently, there is a movement to change this system and to base application rates on P. Simpson (1991) calculated that 18.2 ha of pasture land is required to dispose of manure produced annually in a 20,000 bird house if litter application is limited by N, whereas if P limits on litter application are considered, 91.1 ha of pasture are required. If they did not have the necessary land base, growers would have to transport their manure to areas of lower fertility. Moving manure to areas where soil N and P levels are low would not only improve crop production, but would decrease the likelihood of environmental problems. However, transportation costs would prohibit this practice, unless subsidies for such a program are provided. As soil test P levels increase, P levels in runoff water increase. As a result, at least seven states have placed cutoff limits for soil test P. When soils exceed these levels, it is recommended that growers cease all P applications (including manures) and use commercial N fertilizer to meet crop N requirements (which would increase their operating costs). Therefore, using a P-based manure management strategy may resolve potential environmental issues, but at the same time may be placing unacceptable economic burdens on farmers.

Phytase Addition to Feed

The addition of inorganic P to poultry feed is necessary, since poultry lack the phytase enzyme needed to break down phytate P compounds. Therefore, when phytase enzyme is added to poultry feed, it makes phytate P available. At present, this process is cost prohibitive, at least in the U.S. A more cost-effective method of dealing with phytate would be to develop corn and soybeans through genetic engineering that have less phytate P. Pioneer seed has recently been successful in developing a "phytate-free" corn variety, although results from yield trials are forth coming.

Vegetative Filter Strips

Vegetative filter strips are a low cost management strategy for reducing P runoff from land receiving poultry litter. Chaubey et al. (1993) found that vegetative filter strips reduced both soluble and total P concentrations dramatically in runoff from pastures fertilized with litter. Although filter strips are one of the most effective means of reducing non-point source pollution, they only work properly if sheet flow of water is occurring. When runoff is channelized into gully flow, their effectiveness is greatly diminished.

Aluminum Sulfate Additions to Litter

Moore and Miller (1994) found that addition of chemicals containing Al, Ca, and/or Fe greatly reduced soluble P levels in poultry litter. Since water soluble P is the major form of P in runoff from fields fertilized with poultry litter, P runoff from litter amended with these compounds should be lower than that from fields fertilized with normal litter. This was confirmed in a field study by Shreve et al. (1995) who showed that the P concentrations in runoff from small plots receiving alum-treated poultry litter were 87% lower than plots receiving the same rates of normal litter. Subsequent research has shown that P runoff was 75% lower in watersheds fertilized with alum-treated litter, compared to normal litter. By changing soluble litter P to less-soluble forms, land application of litter can be made based on meeting crop N requirements, reducing the need for commercial N.

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WASTE REDUCTION IN EGG PROCESSING

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Small food processors who have wastewater problems have a severe financial disadvantage in solving these problems due to the high initial capital cost of wastewater pretreatment systems. To operate these systems they must have a trained operator to operate the pre-treatment system. This is an additional cost. To minimize this financial burden, a feasible approach is to reduce the water use and wastewater loading in the processing plant.

A small company that hard cooks and peels eggs was faced with this problem. The BOD concentration could exceed the violation limit of the municipality by a factor of approximately six times. The municipality had served notice to the company that they would cease sewer service if the company did not come into compliance. The municipality, however, agreed to allow the company to try the minimization-conservation approach.

With the conservation-minimization approach approved by the municipality, the company received assistance from Extension Specialists at The University of Georgia, in identifying and correcting those operations which caused excessive organics to be discharged into the waste and those times and operations which use excessive water.

CONSERVATION-MINIMIZATION PROCEDURES

Plant observation determined situations which caused excessive organics in the waste stream.

1. Eggs were brought in on stacked pallets. They were held to allow the eggs to age so that internal quality decreased and an egg with improved peeling characteristics was processed. No attempt was made to determine if eggs had lost sufficient internal quality to

produce eggs with favorable peeling characteristics. To predict peelability, candling of eggs prior to processing was instituted so that there would not be excessive waste due to poor peeling eggs. Candling eggs not only reduced loss eggs but also produced a greater yield of the most valuable product, whole hard cooked eggs.

2. More efficient handling of the citric acid preservation liquid not only reduced waste load but also prevented the low pH citric acid preservation media from destroying the microbes in the biological septic tank treatment system. Review of municipal sampling records revealed that when wastewater exceeded municipal violation limits by five to six times the pH was also below violation limits. To prevent violation due to the citric acid in the waste stream, the person who took the egg waste for pig feed agreed to also take the citric acid solution.

3. Prior to minimization, water used in the cracking unit which contained pieces of broken eggs was allowed to flow into the floor drains. To prevent this source of loading, a vibrating screen was used to recover pieces of cooked eggs from the waste stream. Water from the shaker screen was allowed to settle in a small catchment basin, so that material passing could be captured and sent to the pig man rather than being discharged into the municipal sewer.

4. Screens were constructed and placed into the floor drains to prevent wasted product from entering the waste stream.

5. Equipment was adjusted to prevent product loss. One major point of product loss to the drain was two transfer belts. The gap between the two belts was too large so that smaller eggs would fall into this gap and be crushed onto the floor. By simply placing the belts closer together, floor waste was reduced and more product was recovered for sale.

6. Training of plant personnel was conducted so that they would realize that product wasted to the drain was the cause of the problem. Dry clean-up procedures of floor waste was instituted. This not only reduced wastewater strength but also reduced water use.

7. Constant management attention to product loss produced some interesting results. Eggs were peeled by hand after being discharged onto a belt by the egg cracker. A large amount of floor waste was produced at a work station of a very short peeler. The peeler had to work at shoulder height, whereas, the other peelers worked at waist to

chest height. Providing a stand to the short peeler reduced floor waste at that station.

RESULTS

Using these techniques and constant management attention, water use was reduced by 80 percent and the wastewater strength was reduced to the point that the municipality allowed the plant to continue to operate. Using the minimization approach, the company recovered an additional 300 pounds of eggs each day for sale. Reduction of municipal fines for violations, reduction in water and sewer changes, and enhanced product recovery increased the profitability of the company.

The unsolicited letter on the following page, reprinted with the company's permission, attests to the efficacy of conservation-minimization and the satisfaction of the company with the results.

ALMARK FOODS INC.

June 11, 1996

Bill Merka
University of Georgia
Poultry Science
4 Towers Blvd.
Athens, Ga. 30602

Dear Bill,

Wanted to drop you a line. I hope everything is going well for you. With implementation of your ideas in our plant we have arrived at substantially reduced waste water charges. We have been able to have a low of 222 on BOD from a high in December of 1994, of 5420. We have also, reduced our water consumption from a high in 1992 of 546,788 gallons to a low April of 1996 of 70,312 gallons. Surcharges have gone from a high of $8,049.77 in December 1994 to $67.73 in May of 1996. During this period we have actually increased production by 30%. All of this accomplished by minor changes in plant equipment and procedure.

Bill, thanks so much for your cheerful and professional help. I hope we can work together again soon!

Sincerely,

Mark A. Papp
President

MAP/cc
Attachment

2118 Centennial Drive • Gainesville, Georgia 30504 • (404) 536-4520 • 1-800-849-EGGS • Fax (404) 536-4793

WASTE REDUCTION IN POULTRY PROCESSING

Stephanie Richardson
President
Preventive Environment Management, Inc.
Raleigh, NC

and

Roger Smith
Engineer
Seaboard Corporation
Shawnee Mission, KS

This paper outlines options and results of implemented options presented to Seaboard of Kentucky following a waste reduction opportunity assessment conducted February 6-11, 1994. The focus of the assessment was water conservation and wastewater reduction. Though no in plant follow-up work has been conducted, plant personnel have been contacted for confirmation as to which waste reductions options were implemented. Total results are presented as theoretical and actual after two years of operations.

FACILITY BACKGROUND INFORMATION

Seaboard of Kentucky, a poultry processing facility, located in Hickory Kentucky, first opened in 1990, the facility was designed to process 185,000 birds per day (bpd). In addition to whole bird processing, this facility provides some further processing which is limited to cut up chicken, deboned chicken, and marinated whole birds.

At the time of the assessment, the Seaboard plant was relatively new and well maintained with good lighting and ample room. The facility was equipped with a condemned bird vacuum system and extensive floor drains that were very deep and easily accessible. Grating systems on the floor drains had large spacings in the grill work that can be easily removed.

Normal operations are Monday through Friday with weekend processing limited to times of increased orders or weather related processing slow downs or stoppages. Seaboard of

Kentucky operates two processing shifts and one cleanup shift. Each shift receives two 15 minute breaks and one 20 minute meal break.

On-site wells provide potable water. On an average daily basis, more than 971,000 gallons of water per day was pumped from the wells in 1993. Since there was no meter following water treatment, it was difficult to determine how much water was actually consumed by processing during this time. Per bird usage averaged 8-12 gallons per bird in 1993 but, due to emergency measures taken by the sanitation crew, was reduced to 7 gallons per bird in early 1994.

Cause for Concern

At the time of the assessment, the Seaboard facility was undergoing a 50% expansion that would result in an increase in processing to as much as 271,000 birds per day. This expansion was in jeopardy due to excess water usage that had resulted in excessive wastewater generation and inadequate potable water supplies.

A relaxed attitude toward water usage and wastewater generation developed due to a change in waste handling procedures, caused in part by the expansion construction. Other factors leading to this lax attitude included the ease of accessibility to and volume of the plant drainage system, a wastewater treatment plant that had traditionally had ample capacity, and on-site wells that had offered an abundance of potable water. This relaxed attitude came into clear focus in January 1994 when the wastewater treatment plant filled to within inches of overflowing. In addition to this near catastrophe the wells were being pumped to capacity. Lack of treatment capacity coupled with inadequate water supplies was placing the expansion in jeopardy.

At the time of the assessment Seaboard was operating at more than 7 gpb when the industry standard was 4-6 gpb. Most plants operate at 5½ gpb while better plants achieve 4½ gpb, on average. Additionally, the total 1993 water/wastewater cost had exceeded $1.2 million. The 7 gallons per bird rate had only been achieved following emergency measures to prevent the wastewater plant from overflowing. Before emergency measures the water usage ranged 8-12 gpb.

OPTIONS FOR PROCESSING ACTIVITIES

The following are some of the major options presented to Seaboard. Water and cost savings are based on a 16-hour processing day with 265 days of processing per year. Water and wastewater cost have been calculated at $1.75/1,000 gallons. This cost is a true representation of water/wastewater cost as fixed cost for equipment depreciation and wastewater treatment operators have been removed.

Scalding/Picking Room

At the time of the assessment the scalders were not equipped with flow meters. Due to the nature of the overflow it was not possible to quantify how much water was being wasted. The proposed option was to equip all scalders with flow meters and limit water used in this process to the minimum amount required by the FDA. This would not only reduce water usage and wastewater generation, but this would greatly reduce energy cost. Another important benefit would be elimination of excessive amounts of water spilling onto the floor and running into other areas of the facility.

Evisceration Room

The evisceration room is traditionally the largest water user and wastewater producer in a poultry processing facility. the very nature of these processes leads to waste generation and water usage. This can be reduced through process modification, management approaches and equipment replacement. Actual water flow measurements were taken for each piece of equipment in the evisceration room. Total flow in the evisceration room was calculated to be 344.5 gpm. By actually measuring flows to each piece of equipment, calculations of water and cost savings can be based on actual processing flows instead of theoretical flows.

<u>Processing Option #1: Eliminate Giblet Processing</u>: Although numbers were presented to Seaboard on the cost and water savings associated with reducing water used in the transfer of the giblets, the option was to eliminate giblet processing and include giblets in offal sales.

Table 1 reflects only partial cost savings associated with the elimination of giblet processing. An equivalent in giblet sales is shown to prove the feasibility. It should be noted that these savings only reflect water and wastewater costs associated with pumping the giblets. These savings do not include energy costs, manpower cost for inspecting the giblets or water used through good necks at inspection stations.

Through reduction, transfer pump water can be reduced by more than 6 million gallons per year, but there will still be the pollutant loading associated with giblet transfer. As giblets are transferred via water, fats, oils, and bits of solids dissolve in the water. These materials have a very high pollutant loading which the wastewater treatment plant must handle. Elimination of giblet processing would reduce both the hydraulic and pollutant loading on the wastewater treatment plant. This coupled with the fact that giblets are sold for less than a $.50/pound clearly pointed to the feasibility of this option.

TABLE 1. Water and cost savings associated with eliminating giblet processing

Proposal	Eliminate giblet processing & sell giblets with offal
Water savings	19,334,400 gallons/year
Cost savings	$ 33,835/year
Equivalent giblet sales	93,988 pounds/year to dover cost of transfer pumps alone

<u>Processing Option #2: Goose Neck Faucet Elimination & Replacement</u>: Goose neck faucets have traditionally been one of the greatest water wasters in poultry processing. Goose necks at the Seaboard facility had originally been equipped with hand push on/off mechanisms. Employees quickly "modified" these so that water flow was continuous. Additionally, a review of the plant during processing showed that many goose necks were in areas where they were totally unused, and very few were in continuous use.

The option regarding goose necks was to eliminate those not used and replace others with low flow goose necks. An additional option included the installation of on-demand mechanisms which could be knee or foot activated systems.

Table 2 outlines water and cost savings associated with replacement of goose necks in the evisceration room alone. This assumes replacement of all goose necks and does not take into account those which should be eliminated nor does it take into consideration further savings possible with on-demand devices. Although the installation of low flow goose necks equipped with on-demand controls was recommended for all areas of the plant, cost and associated savings are only shown for the evisceration room.

TABLE 2. Water and cost savings associated with goose neck replacement

Proposal	Replace existing goose necks with low flow (.5 gpm) goose necks
Water savings	26,839,200 gallons/year
Cost savings	$ 46,969/year
Installed cost	$ 1,075
Payback period	9 days

Processing Option #3: Hand Whirlpool: The hand whirlpool was a device that allowed employees to place their hands into warm agitated water when they became too cold or stiff. Although never observed in use, the employees indicated that access to this device was important so it should not be slated for removal. As designed, the whirlpool was very deep tank that had a hose placed in it to provide hot water. The hose ran continuously providing both the hot water and the agitation. Overflow from the tank was 4 gpm. The proposed option was to redesign the tank to eliminate the overflow. Table 3 provides details on the proposed action and associated savings. Note that this does not reflect the potential in energy cost savings.

TABLE 3. Water and cost savings associated with hand whirlpool modifications

Proposal	Use a smaller container, remove hot water over flow, add air for agitation, fill with cold water and add a heating element
Water savings	1,017,600 gallons per year
Cost savings	$ 1,780/year

Processing Option #4: Turn Water Off During Breaks and Shift Change: As employees leave for lunch or to take their two 15 minute breaks there is a quick wet cleanup. Although no birds are being processed, processing water to equipment continues to flow. This not only occurs during the shift but at shift change as well. The sanitation crew indicated that the continuous flow of water to process equipment in no way facilitated their cleanup activities. This option proposed the installation of instrumentation that would allow a single switch to turn water off to all processing equipment in the evisceration room during breaks, meals and at shift change. Table 4 provides a break down of the water and cost savings associated with this option.

TABLE 4. Water and cost savings associated with turning water off during breaks

Proposal	Install instrumentation that would allow a single switch turn off of processing water when processing ended
Water savings	13,693,875 gallons/year
Cost savings	$ 23,694/year

OPTIONS FOR SANITATION/CLEANUP

Several options were presented for the sanitation and cleanup activities. Due to the nature of these activities, quantifying water or cost savings was impossible. Both of the options presented in this paper involve the sanitation crew.

Sanitation Option #1: Reduce Sunday Evening Reclean Activities: The facility is fully cleaned and sanitized Friday night/Saturday morning following the end of weekly processing. At the time of the assessment the procedure was to repeat this activity in full again Sunday evening before start-up. The desire to re-sanitize is understandable however the need to perform a full clean and sanitization process is wasteful, particularly with regard to CIP (clean in place). The option outlined here was to reduce the Sunday evening cleanup to more of a basic sanitation pass only, without a full cleanup.

Sanitation Option #2: Conduct CIP Correctly: Clean in place procedures are designed to be closed-loop. The purpose is to clean and sanitize piping with minimal amounts of water and chemicals. At the time of the assessment this is not how CIP was being conducted at the Seaboard facility. The approach used was open ended. Water was allowed to continuously flow through the piping, fill the chiller and then out. This meant that once detergents were added and the chiller was filled with "soapy water," it was not circulated and then dumped. Instead clean water was introduced, dilution took place, and this dilution process continued until the water ran clean. CIP should run similar to a batch system where the detergent water is circulated for a set amount of time and then drained. Rinse water is introduced and repeats this scenario as do the additional rinses and disinfection chemicals. The proposed option was to run the CIP in this batch manner.

MISCELLANEOUS/MANAGEMENT OPTIONS

Miscellaneous Option #1: Turn Water Off to Vacuum Pumps When Not in Use: Seaboard of Kentucky has water cooled vacuum pumps. The water to these pumps ran continuously at 108 gpm even when no processing was taking place. Inspection of the pumps showed that they were set up to handle solenoid switches that would stop the flow of water when they were not in use. the proposed option was to install solenoid switches so that cooling water flow to the pumps would be restricted to the times when they were in use. A further step was to investigate reuse/options for the cooling water. Table 5 outlines the water and cost savings associated with this option.

Miscellaneous Option #2: Monitor and Chart Water Usage by Shift: This option falls into the management category. Although not direct water or cost savings can be calculated for this option, it can go a long way toward reducing water usage. By monitoring and charting water usage for each shift, one can easily see any trend toward increased water usage, determine quickly if one shift is using more water than another and take immediate actions needed to correct the situation before they get too far out of hand.

TABLE 5. Water and cost saving associated cooling vacuum pumps only when in use

Proposal	Install solenoid system that stops the cooling water flow when pumps were not in use, eliminating flow on weekends
Water savings	16,174,080 gallons/year
Cost savings	$ 28,304/year

RESULTS

Theoretical results of implementing all the options presented, based 1994 processing levels of 185,000 birds per day for 265 days per year, are shown in Table 6.

TABLE 6. Theoretical total cost and water savings associated with presented options

1994 Levels	$600,556/yr	343,175,000 gal/yr	7.00 gpb
Giblet elimination	33,835/yr	-19,334,400	-0.39
Goose neck replacement	45,969/yr	-26,839,200	-0.55
Hand whirlpool mod.	1,789/yr	- 1,017,600	-0.02
Shut off water during breaks	23,304/yr	-13,693,875	-0.28
Limit water flow to vacuum pumps	28,304/yr	-16,174,080	-0.33
Theoretical totals	$465,974/yr	266,115,845 gal/yr	5.43 gpb

Since real world and theoretical do not always coincide, and since Seaboard of Kentucky did not implement all the options presented, the results of the assessment differ from the theoretical results. Table 7 presents a listing of options, whether or not they were implemented and reasons why they were not implemented.

Table 8 presents data, current as of mid-May 1996, which shows that water usage has been reduced to 5 gpb, on average. Data is presented at processing levels of 185,000 birds per day to allow direct comparison with 1994 levels and at the current processing level of 255,000 bpd.

CONCLUSION

If 1994 production levels had remained the same Seaboard of Kentucky would have realized and annual water savings of 63,242,250 gallons and cost savings of $110,674 through water conservation measures. **Water conservation** measures coupled with continued attention to usage not only allowed Seaboard to bring their expansion on-line as scheduled, but have **resulted in 48% increase in production with only a 13% increase in water usage.**

TABLE 7. Options summary

Option	Implm't	Reasons Why Not
Install scald water meter	Yes	
Elim. giblet processing	No	None given
Goose neck replacement	Yes	goose necks replacement complete, on-demand devices
with on-demand devices	No	present maintenance problems - efforts continue
Hand whirlpool modif.	Yes	
Turn water off during breaks, meals & shift change	No	Attempted individual machine manual approach-confusing -- have not tried single switch approach
Reduce Sunday reclean	???	No information available
Correct CIP procedure	???	No information available
Reduce water to	Yes	Awaiting permission to reuse
vacuum & reuse water	Yes	treated wastewater as cooling water for pumps
Monitor/chart water usage by shift	Yes	

TABLE 8. Total water usage and cost comparisons

Year	Gallons/bird	Birds/day	Gallons/year	$$/year
1994	7.00	185,000	343,175,000	600,556
1996	5.71	185,000	279,932,750	489,882
1996	5.71	255,000	385,853,250	675,243

WASTE MINIMIZATION IN THE FEED INDUSTRY

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The animal feed manufacturing industry has long been acknowledged as a leader in waste minimization. Decades ago we discovered that waste products from other food related industries had valuable properties such as protein content and fiber. In 1994, it was estimated that the animal feed industry used 45 million tons of other industry's by-products in the manufacture of 122 million tons of animal feed. That is 45 million tons of materials that did not go to the landfill! Putting this volume in terms we can all picture, if the 45 million tons were spread over Washington D.C., the city would be 17" deep in bull puckey then it is today.

However, the feed industry realizes that we must go far beyond our current activities and do our part on further reducing materials that are sent to the landfill. Our realization is based upon knowledge of the problems our country is facing with closing landfills. We are aware that the number of landfills has dropped from roughly 14,000 in 1978 to only about 4,000 today. We are aware that the projection for 2003 is that only 1,500 of these landfills will remain.

The primary source of solid waste in our industry is from packaging materials, specifically the ingredient bags and our product bags. The Paper Shipping Sack Manufacturers' Association (PSSMA) calculated that in 1993, 400 million multiwall paper shipping bags were sold to the feed industry. Another estimated 350 to 400 million bags were used by the feed industry through ingredient suppliers. That is 800 million paper bags requiring disposal. But as large as this number may seem, it represents only 0.1% of the solid waste stream in the U.S.

Another common waste at a feed mill is recalled feed and cleanout from liquid ingredient storage tanks such as animal fat or molasses. Both of these items are composed of entirely biodegradable items. As an option to landfill disposal, work with the local or state environmental agencies to find areas where these items can be land farmed. By plowing these wastes back into the soil, they can degrade and provide usful soil nutrients or conditioning agents.

A third common waste stream at a feed mill is broken or unusable pallets. Pallets are reused in our industry yet plastic pallets do have a finite life, and eventually must be disposed. Several successful local programs result in plastic pallets being recycled into fuel pellets. We have attempted to work with several regional companies for recycle purposes, but again have met with several obstacles.

The American Feed Industry Association has established a Solid Waste Task Force to help address waste reduction. Every year at the National Convention, AFIA Environmental Awards are presented to recognize operating facilities, their management and their employees who have made improvements in waste reduction.

EXTRUSION PROCESSING OF HATCHERY WASTE AND EGGSHELLS

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The poultry industry is generating a considerable amount of by-products that need to be disposed of. The options of disposal are limited and costly. the most common practices of by-product disposal are sanitary landfills, rendering, extrusion, composting, disposal pits, closed lagoons or holding tanks, and land application (Pope, 1991). Because of today's environmental concerns and regulations and the fact that all the above options, excluding rendering and extrusion, do not lend themselves to any economical advantage in terms of utilizing the nutritional value of those secondary resources, these options are not practical and have no future.

For a given processor, rendering may be an option if the volume of by-products is large enough to justify the capital investment of a rendering plant. However, in most cases, an independent renderer may take the by-products while the processor pays the transportation fees. A common practice of a given renderer is to separate the hatchery liquid from hatchery waste. The liquid is then dried and sold while the solids containing the eggshells and other residues may be taken to sanitary landfills. Eggshells generated from egg breaking plants are normally disposed of in landfills or spread on fields. Several investigators have studied the feasibility of processing hatchery waste or eggshells utilizing high temperature, short-time (HTST) extrusion technology. All of these studies indicated a high quality, pathogen-free product when either hatchery waste or eggshells were co-extruded with low moisture and/or low fat ingredients.

PROCESSING EGGSHELLS

Froning and Bergquist (1990) recycled extruded eggshell product (ESP) into laying hen diets. The ESP comprised of 70% centrifuged eggshells, 8% technical albumin, 5% corn, 17% soybean meal and 0.15% propionic acid. Feeding ESP (Table 1) to commercial layer flocks resulted in a significant improvement ($P<0.05$) in egg production as compared to the control diet. No differences were observed in other criteria studied (Table 2). They concluded that there is a potential for utilizing eggshells with other ingredients including inedible albumin in laying rations for chickens. They reported that the extrusion process also provided distribution of Salmonella and the insurance against spreading of disease among egg-laying flocks.

TABLE 1. Compostion of extruded egg shell product (as is basis)

Components	Percentage[1]		
Moisture	9.23	±	.53
Crude fat	.70	±	.35
Crude protein	13.09	±	.75
Digestible protein	10.44	±	.75
Nitrogen-free extract	34.08	±	5.16
Ash	37.43	±	1.45
Calcium	23.95	±	.20
Phosphorus	.24	±	.09

[1] x ± SD.
Froning and Bergquist (1990).

TABLE 2. Effect of feeding extruded eggshells on shell quality, rate of lay, feed conversion and mortality

Treatment Group	Breaking strength[1]	Shell thickness[1]	Rate of lay[2] (hen housed)	Feed conv.	Mort.[2] per 1000 birds
	(kg)	(mm)		(kg feed per doz. eggs)	
Control	4.44[a]	.384[a]	62.4[b]	1.89[a]	1.15[a]
Extruded	4.54[a]	.394[a]	64.2[a]	1.77[a]	2.1[a]

[a,b]Values in the same column with no common superscripts are significantly different (P<.0.05)
[1]Breaking strength and shell thickness were measured on two replicates of 30 eggs each (a total of 60 eggs per treatment).
[2]Weekly averages were taken over a 12-week period.
Froning and Bergquist (1990).

In two experiments, Tadtiyanant et al. (1993) blended 75% centrifuged eggshells (two different sources) with 25% corn prior to extrusion. Feeding extruded eggshell-corn blend to laying hens had no significant effect on egg production compared with the control diet. No differences ($P>0.05$) were found in egg production due to the source of eggshells. No significant effect ($P>0.05$) was found on all other criteria studied (Table 3). The microbiological test indicated that the pre-extrusion material had significant numbers of colony-forming units per gram of sample while the extruded products were free of aerobic microorganisms (Table 4).

PROCESSING HATCHERY WASTE

Vandepopuliere et al. (1977) incorporated dried waste from broiler and egg-type chick hatcheries at levels of 8 and 16% in laying hen diets. The hatchery waste (Table 5) substituted soybean meal, meat and bone meal, wheat middlings and ground corn. Feeding those two products resulted in similar performance of hens fed the control diet.

Tadtiyanant et al. (1993) fed broiler hatchery solids, hatchery liquid or reconstituted hatchery waste from two different sources co-extruded with corn to laying hens. Feeding the resulting extruded products had no significant differences ($P>0.05$) on egg production, egg weight, feed conversion, and egg specific gravity as compared to layers fed the control diet (Table 3). The microbiological test indicated that the pre-extrusion blended mixtures had significant numbers of colony-forming units per gram of sample. The extruded products that exited the barrel of the extruder were free of aerobic microorganisms. They reported that the results of these studies indicated that high temperature, short-time extrusion is an alternative method for converting these poultry industry residues into feedstuffs.

Many industry leaders are faced with the reality of the current environmental regulations and it's impact on their growing business. One of these leaders is Hy-Line International. Having earned a larger share of the layer genetics market, their increase in chick production naturally resulted in an increase of hatchery waste from the breeder hatchery.

Hy-Line investigated the existing options of disposal for their eggshells, infertile eggs, unhatched embryos and off-line chicks. Realizing that it is neither acceptable nor economical any more to take the hatchery waste to a land dump, a decision was made to install an extrusion plant to process the waste stream. The project was supported by the Department of Natural Resources to provide the poultry industry in Iowa

TABLE 3. Effects of extruded eggshells, hatchery waste and turkey deboning residue on laying hen performance (Experiments 3 & 4)

	Hen-day production		Egg weight		Feed converions (Feed:egg ratio)		Egg specific gravity		Haught Units	
Dietary Treatments	Exp. 3	Exp. 4	Exp. 3	Exp. 4	Exp. 3	Exp.4	Exp. 3	Exp. 4	Exp. 3	Exp.4
	%		g		g/g					
Control	76.2	77.3	65.1	66.3	2.27	2.15	1.0624	1.0801	81.1[ab]	81.1
Corn-eggshells[2]										
Source A	83.1	77.2	63.4	65.4	2.17	2.16	1.0826	1.0829	81.2[a]	80.4
Source B	80.2	73.3	64.2	66.1	2.20	2.27	1.0830	1.0800	79.8[b]	82.4
Corn-hatchery solids[3]										
Source C	81.6	76.7	64.6	66.2	2.39	2.25	1.0830	1.0790	81.2[a]	80.0
Source D	82.8	74.6	64.4	65.6	2.20	2.26	1.0821	1.0709	79.8[b]	81.2
Corn-hatchery reconstituted[4]										
Source C	82.2	79.2	64.5	65.9	2.19	2.18	1.0824	1.0794	79.4[b]	81.3
Source D	79.9	75.3	64.2	65.8	2.29	2.21	1.0815	1.0790	82.1[a]	78.0
Corn-mechanically deboned residue[5]	82.0	76.3	64.1	65.2	2.13	2.13	1.0823	1.0791	79.5[b]	78.0
SD, pooled	2.93	3.36	.53	.79	.06	.07	.0813	.0015	1.70	2.15

[ab]Means within a column with no common superscripts differ significnatly ($P \leq 0.05$).
[1]Means of six group of cages, 30 laying hens per group.
[2]Ground corn and centrifuged eggshells in a 25:75 ratio (wet basis).
[3]Ground corn and cedntrifuged hatchery solids in a 40:60 ratio (wet basis).
[4]Ground corn, centrifuged hatchery solids and liquid in a 65:19.6:15.4 ratio (wet basis).
[5]Ground corn and mechanically deboned residue in a 73.2:26.8 ratio (wet basis).
Tadtiyanant *et al.*, 1993.

TABLE 4. Aerobic plate count of dead poultry, feathers, eggshells, hatchery waste and deboning residual mixtures before and after extruding

Source	Before Extruding			After Extruding		
	Exp. 1	Exp. 2	X	Exp. 1	Exp. 2	X
			(cfu/g of sample)			
Broilers, 3 wk[1]	2.0×10^5	4.0×10^6	2.1×10^6	0	0	0
Broilers, 4 wk[1]	2.0×10^5	3.0×10^6	1.6×10^6	0	0	0
Turkey, 6 wk[1]	4.5×10^6	8.0×10^5	2.6×10^6	0	0	0
Turkey, 12 wk[1]	3.2×10^4	6.0×10^5	3.2×10^5	0	0	0
Feathers[1]						
Untreated	5.0×10^5	3.5×10^5	4.2×10^5	0	0	0
Treated[2]	3.5×10^5	2.8×10^5	3.2×10^5	0	0	0
	Exp. 3	Exp. 4	X	Exp. 3	Exp. 4	X
Eggshells[3]						
Source A	8.5×10^5	3.9×10^8	2.0×10^8	0	0	0
Source B	1.5×10^5	1.1×10^9	5.6×10^8	0	0	0
Hatchery solids[4]						
Source C	6.9×10^8	2.5×10^{10}	$13. \times 10^{10}$	0	0	0
Source D	2.2×10^8	3.9×10^9	1.9×10^9	0	0	0
Hatchery reconstituted[5]						
Source C	4.0×10^7	1.7×10^8	1.0×10^8	0	0	0
Source D	1.5×10^6	2.2×10^9	1.1×10^9	0	0	0
Mechanically deboned residue[6]	2.2×10^8	5.6×10^7	1.4×10^8	0	0	0

[1]Mixtures of 75% soybean meal (48% Cp) and 25% dead birds or feathers (wet basis).
[2]Treated by proteolytic enzymes premix (2.5% wet basis). Enzyme Premix No. 1995 provided by Instra-Pro International, Des Moines, IA.
[3]Ground corn and centrifuged eggshells in a 25:75 ratio (wet basis).
[4]Ground corn and centrifuged hatchery solids in a 40:60 ratio (wet basis).
[5]Ground corn, centrifuged hatchery solids, and liquid in a 65:19.6:15.4 ratio (wet basis).
[6]Ground corn and mechanically deboned residue in a 73.2:26.8 ratio (wet basis).
Tadtiyanant *et al.*, 1993.

and nationally with a model to learn from. It also provides Hy-Line International with an answer to the question that was frequently asked by their customers worldwide, "What can we do with the by-products?"

The trucking charges and landfill fees that approached $100,000 per year to haul away an average of two tons of hatchery waste per day were eliminated. The finished product is being sold as an ingredient for layers and as a supplement for beef cattle. Currently, Hy-Line is working on expanding the project to process spent hens.

In the design of the extrusion processing plant, bio-security was one of the priorities. Located 150 feet from the hatchery, the processing plant receives hatchery waste through an underground vacuum system. The hatchery waste is then blended with an equal amount of a carrier (soybean meal - 44% crude protein) to reduce the moisture content to about 40%. From the mixer, the blended product is transferred to a holding bin that can feed the extruder via a conveyor through a wall separating the cooked from the raw material.

The extruder cooks the product in less than 30 seconds utilizing friction as the only source of heat. A temperature sensitive air gate system assures that only properly cooked product will be transferred to a dryer. The dryer then reduces the moisture content of the extruded product from 30% to 10%. The product is then cooled through a simple tumbling action prior to storage. The nutritional and microbiological quality of the finished product is monitored regularly to assure the wholesomeness of the new ingredient.

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TABLE 5. Amino acid and proximate analyses of two types of hatchery by-product meal

	Hatchery by-product meals	
	Broiler	Egg-Type Chick
	%	
Aspartic acid	1.93	2.83
Threonine	0.88	1.27
Serine	1.04	1.70
Glutamic acid	3.34	5.15
Proline	1.87	2.78
Alanine	1.04	2.10
Cystine	0.57	0.65
Valine	1.39	2.07
Methionine	0.62	0.77
Isoleucine	1.22	1.70
Leucine	2.01	3.00
Tyrosine	0.37	0.96
Phenylalanine	0.85	1.48
Histidine	0.40	0.57
Lysine	1.16	1.83
Arginine	1.59	2.35
Total	21.79	33.67
H_2O[1]	65.00	71.00
Protein	22.20	32.30
Calcium	24.60	17.20
Phosphorus	0.33	0.60
Fat	9.90	18.00

[1]Raw, before dehydration.
Vandepopulier et al., 1977.

ENVIRONMENTAL MANAGEMENT SYSTEM
COMPUTER DATABASE COMPONENT

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Environmental Management Systems (EMS) are defined and/or referenced in both the federal government's sentencing guidelines and in the recently published ISO 14000 international environmental standards. Companies faced with the sentencing guidelines are credited with reduced fines and jail time for having an effective EMS in place. Companies looking for certification under the ISO standards will learn that an EMS is considered one of its key components.

How should EMS be interpreted by an agribusiness such as the poultry industry? What standard of care, or at least, what first steps should be taken to survive a federal sentencing investigation? What will ISO certification firms look for in an EMS? These questions are ones that this writer has asked repeatedly to in-house attorneys, outside council and consultants and other company environmental managers. The responses have varied in complexity but most have a similar theme. 'Make sure the EMS can show that your company routinely reviews information that documents compliance and that responsibility for compliance at all levels is communicated and also documented'. In summary, at any time if you are asked 'Are you in compliance?' you should be able to produce the papers that proves it. This paper provides a brief review of the initial step that Continental has taken to come to terms with the EMS concept. This initially is the development of a computerized data management system.

AN ENVIRONMENTAL DATABASE

The best place to start in developing an EMS is in organizing all of the information that is required by a company's permits and plans. A company which operates only one or two facilities may choose to do this by making a simple list or by marking a calendar with actions required by the facility's plans and permits. Items on the list or calendar can be initialed to indicate who and when each requirement was completed. This system with good files may suffice in demonstrating compliance. The task of organizing and documenting compliance for more than just a handful of facilities using only paper records though can become very time consuming. Computers can serve a useful role in these larger multi-facility organizations.

With over 200 facilities, continental recognized the need to use computers to assist in demonstrating compliance. About two years ago, several "off-the-shelf" databases were evaluated. the cost and complexity of these programs were evaluated and each program was tested to see if it would fit with the types of businesses the company owns and manages. (These businesses are primarily agricultural industries such as poultry processing.) Continental determined after a short while that the "off-the-shelf" market seemed to be geared more toward heavier industries such as chemical manufacturers and large quantity hazardous waste generators.

As a result, Continental opted for a system developed in-house. The software chosen for programming was paradox 5.0 for Windows. The database took about one year to develop. The cost was moderate (less than many off-the-shelf systems) and is now fully functional in the company's poultry division and about 80% functional in its pork and cattle divisions. Other divisions are beginning to collect data for eventual input. A description of the basic functions and usefulness of the database follows.

Database Function and Uses

Basic information about each facility is entered into the database such as facility address, emergency facility contacts, permit numbers, longitude and latitude, number of employees, types of water and wastewater systems, acreage, acquisition year, etc. This data can be conveniently used for completing permit applications or other documents that require facility specific data (i.e. longitude and latitude). the data also can be used in the event of an emergency or other event which requires quick access to facility specific data. Since the data has been entered into a software package that can sort data fields and provide printed reports, data can be sorted at times when new regulations are promulgated so that an environmental manager can zero in quickly on potentially affected facilities. An example would be if a new drinking water standard were promulgated which affects facilities with private wells and more than 25 employees in EPA Region X. By simply running an exception report using these three criteria (three data fields in the database) the manager can determine which facilities will be effected. Another useful example is to query the database to determine which facilities you may have that pump water from a well but do not have a drinking water permit. Exception reports of this nature can be instrumental in finding omissions in facility planning and permitting.

Very specific permit and plan data is also entered into the database. Data entered here include items such as fees, signatory authority, state contact names and telephone numbers and significant permit history. Also entered are date sensitive information associated with the permit such as reapplication and expiration dates, tasks which are required by the permit such as submission deadlines for reports to the state or sampling deadlines for storm water sample collection. This date sensitive data is the most important and valuable part of the package. By entering the data as either a one time event or one that occurs with a selected frequency such as weekly or monthly, reports can be generated for each facility or division. These reports take the form of a calendar. By providing these calendars to each facility on a quarterly basis, managers have a tool to track their requirements and a tool to report back to the corporation (also quarterly) that all actions required by their plan and permits have been completed.

The use of a computer database as the basis for an EMS in Continental has been a tremendous success. Not only do division and corporate officers find it useful in demonstrating their compliance but facility managers are quite pleased with the calendar concept. Agribusiness managers are often asked to perform multiple functions. Environmental management is only small percentage of their daily responsibility.

TITLE V OF THE CLEAN AIR ACT

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Title V of the Clean Air Act has been a major source of controversy since its inception. By definition, if a facility has the "potential to emit" in excess of 100 tons per year of a criteria pollutant, 10 tons per year of a Hazardous Air Pollutant (HAP) or 25 tons per year of a combination of HAP's, that facility would be classified as a Major Source of air pollutants. To determine "potential to emit" we were required to calculate our emissions based on uncontrolled operations at maximum capacity 24 hours per day, 365 days per year. In addition, some states required Total Particulate emissions be used in determining a facility's status rather than the federally regulated PM-10, particulate matter less than 10 microns in size. Under this criteria, virtually every feedmill in the country would be a major source of particulate emissions. These criteria are unrealistic in relation to the operation of our feedmills. It is estimated that this definition of "potential to emit" would represent emissions in excess of 50 times greater than what is actually emitted.

The ultimate result of this action is that the Environmental Managers were inundated with paperwork related to the application for Clean Air Act operating permits. We were also facing thousands of dollars per year in permitting fees, as well as major capital expense in acquiring additional and unnecessary control equipment for our facilities. The burden related to this situation was overwhelming, as well as unrealistic.

The National Grain and Feed Association (NGFA) and the American Feed Industry Association (AFIA) were two of the leaders in addressing this problem, with the assistance and support of many State and Regional Agribusiness Associations. Much research has been conducted and time and effort spent in determining realistic assumptions under which to determine a facility's potential emissions. As a result of the hard work and dedication of those involved, an agreement has been reached with EPA which will undoubtedly ease the regulatory burden thrust upon the industry by Title V. The major points in this agreement which will have a positive effect on our industry are as follows:

1. New emission factors have been adopted, known as the "Interim AP.42" tables. The new tables are based on extensive research throughout the feed and grain industry and will correct the extremely high estimates represented in the previous AP.42 tables. The new tables will reduce a facilities potential to emit by approximately 95%.

2. PM-10 will be the regulated pollutant for feedmills and grain handling facilities. Previously total particulates were used in many states. This will reduce potential emissions by approximately 75%.

3. Pollution control devices which are "inherent" to the feed manufacturing process, for example pellet cooler cyclones, shall be considered in determining a facility's "potential to emit".

4. More realistic assumptions may be considered in determining "potential to emit." Rather than basing calculations on maximum capacity 8760 hours per year, changes in program philosophy allow for a more realistic approach. Bottlenecks and other limiting factors, seasonality for example, can dramatically reduce potential emissions.

The result of this agreement is that only the largest of feedmills will be classified as major sources of particulate emissions. Sample calculations using the above criteria show that in some cases a feedmill with an annual throughput as high as 750,000 tons per year would not exceed threshold levels. This obviously depends on the efficiency of the process equipment in place, a prime example being the efficiency of the pelleting system cyclones. It has been estimated that this will save the industry over 10 million dollars in costs related to compliance with the Clean Air Act.

REGULATORY UPDATE

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Poultry processing facilities are governed by numerous environmental regulations that can have significant impact on operations. Wastewater discharge regulations are the primary issue, but storm water, the Emergency Planning and Community Right-to-Know Act (EPCRA), Title V air permitting, and others are impacting facilities. Future requirements for Risk Management Programs under the new Clean Air Act will further increase the regulatory load. This paper will present an update of the environmental regulations that impact the poultry processing industry. The discussion will include suggestions regarding compliance with these regulations that minimize the cost to the facility.

INTRODUCTION

A detailed overview of the regulations that impact poultry processors is included in Walsh (1995). Walsh and Ray (1996) provides an update of these regulations and expands the scope to include food processing in general. Most of the information in these papers has not changed. Therefore, this paper will only provide updates as necessary.

WASTEWATER

Nutrients

All poultry processing facilities generate wastewater that requires disposal. The discharge of this wastewater is usually permitted for either direct discharge to a receiving stream, to a publicly owned treatment works (POTW), or a land application system. A general trend has been for a reduction in the allowable discharge limits in these permits, particularly with regard to nutrients. The total Kjeldahl nitrogen (TKN) and, in some cases, the ammonia nitrogen allowable discharge limits have been reduced and surcharge rates increased.

Slug Discharge, Spill Prevention Control Plans

Provisions for slug discharge, spill prevention control plans for significant industrial users (SIUs) have been in the regulations for some time. However, in recent years, some POTWs have started to implement the requirement for these plans due to problems with certain dischargers. Some POTWs are requiring these plans from dischargers who are not significant industrial users (SIUs).

Trucking Off-Site

The trucking of wastewater from a facility for transport to another facility that can safely discharge the wastewater is not recommended under normal conditions. A truck is not considered to be an acceptable "method of conveyance" by regulatory agencies. However, one facility found this necessary after the release of ammonia into a heat exchanger when the POTW would not allow the discharge.

Septic Systems

Hatcheries often use septic systems as a method of disposal of wastewater. A septic drain field that is properly designed to handle the hydraulic, organic, and nutrient loading from a facility is essentially a sub-surface land application system. Some states requlate these systems as such. These states may require the installation of monitoring wells similar to those at surface land application systems. Some states, such as Georgia, are attempting to prohibit the use of septic systems for anything except sanitary wastewater.

Spill Prevention Control and Countermeasures (SPCC)

An SPCC plan must be developed by a facility that stores a total of more than 1,320 gallons of oil on-site or more than 660 gallons in a single tank. The oil may be of any type or form which includes hydraulic, cooking, or diesel oil. The requirements for the plan are specified in 40 CFR 112. The plan must be signed by a registered professional engineer. Facilities should carefully check distributed hydraulic systems since a leak at one such system resulted in the loss of approximately 1,500 gallons of oil.

STORM WATER

Most states have adopted the general permit system for storm water discharges. The key variable is the requirement for sampling. Some states require sampling at any animal slaughter and some tie the sampling requirement to the submission of Form R under EPCRA while other have neither of these requirements.

AIR PERMITS

The Title V air permitting program has been approved for most states. The requirements of this program have been eased, particularly with regard to enhanced monitoring. In addition, some states have developed classifications of insignificant and trivial sources.

Feed mills may require a permit due to the emission of fugitive dust. Using the "potential to emit" computation requirements for a major source under the Title V permitting, a feed mill may exceed the 100 ton per year threshold and require a major source permit or obtain a synthetic minor source permit and restrict operations. The issue can become complicated due to the classification of cyclonic separators or bag houses as pollution control devices or process equipment. If tax credits were taken for purchase of these devices as pollution control equipment, the equipment must be considered as pollution control devices in the potential to emit analysis.

EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW ACT (EPCRA)

Poultry facilities use several chemicals that have environmental compliance requirements under EPCRA which is also known as the Superfund Amendments and Reauthorization Act (SARA) Title III, Community Right-to-Know provisions. These chemicals include ammonia in refrigeration systems, chlorine for water and wastewater disinfection, and metal compounds used in feeds.

Walsh and Foley (1990) are suggested for guidance on estimating releases. However, the new threshold determination methods supersede the guidance in this publication. This guidance establishes a new threshold of 1,000,000 pounds for any chemical for which the release is less than 500 pounds. A certification form is submitted in lieu of a Form R. The new threshold may eliminate the need for submission of Form R for feed mill operations.

A number of enforcement actions have been taken regarding the various requirements of EPCRA. Several food processing facilities have been fined for failure to provide either material safety data sheets (MSDSs) (or letters listing applicable MSDSs) to the state emergency response commission (SERC), local emergency planning committee (LEPC), and local fire department; file Tier II hazardous chemical inventory reports with these same agencies; report releases of ammonia; and file Form Rs as a part of the Toxic Release Inventory (TRI).

One EPA region has an unofficial policy that, if a facility determines that they should have filed Form R and does so on their own, EPA will take no enforcement action. If EPA finds the problem, fines will be imposed. However, a facility must file for all calendar years back to 1987 if they find that they should have done so. One processor was fined for failure to file forms for previous years. In addition, this same EPA region has a program where they are using inspectors associated with American Association of Retired Persons (AARP) in the enforcement program.

SOLID WASTE

There are currently no direct solid waste regulations that impact poultry processing facilities. However, restrictions on landfills may impact the material that is disposed of in the trash by a plant. Some plants have added waste to energy boilers for disposal of wax coated cardboard containers that may require permitting under the air permit requirements. If a plant has installed one of these systems, it is suggested that the regulatory agency be contacted regarding any permitting requirements.

HAZARDOUS WASTE

Analyses have found the fluorescent light bulbs contain sufficient mercury to make these a hazardous waste. The old bulbs should be returned to the supplier or a recycler. Some states allow the shipment of these materials with a bill of lading while other require the use of a hazardous waste manifest. In addition some fluorescent light bulb ballast contains PCBs which require special disposal methods for the waste.

RISK MANAGEMENT PROGRAMS

The Clean Air Act amendments established the requirements for facilities with more than the threshold quantity of listed chemicals on-site at any one time to development a risk management plan. The requirements are specified in 40 CFR 68. The threshold quantity for ammonia is 10,000 pounds and for chlorine is 2,500 pounds. The rules for the plan were

approved in May 1996 and facilities will have three years to develop these plans.

OTHER

While not a USEPA requirement, the Occupational Safety and Health Administration (OSHA) regulations in 29 CFR 1910.120

requires that a facility with an on-site emergency response team for handling any problems which involve the accidental release of ammonia provide this team with training. As a minimum, each member of this team must have 24 hours of training which qualifies this team at the technician level of the OSHA regulations. This would authorize the team to enter the ammonia contaminated area and stop the leak per the OSHA standards.

SUMMARY

Poultry and other food processing operations continue to encounter more environmental regulations, and fines and penalties associated with non-compliance are becoming more common. In other food processing operations, criminal indictments for non-compliance have occurred.

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RISK MANAGEMENT PROGRAMS

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On June 20, 1996, the Environmental Protection Agency (EPA) published a new rule, "Accidental Release Prevention Requirement; Risk Management Programs Under the Clean Air Act, Section 112(r)(7)." Compliance must be achieved by June 21, 1999. This has a direct effect on the Poultry Industry because of ammonia refrigeration systems used in poultry processing.

This paper will discuss the new requirements of the EPA Rule, the guidance available to achieve compliance, and the relationship among the EPA Rule, and the Occupational Safety and Health Administration (OSHA) Standard "Process Safety Management of Highly Hazardous Chemicals" (PSM) and Community Right-to-Know laws. A review of compliance inspections for PSM in Delaware will be given along with recommendations to improve compliance.

WHY IS AMMONIA REGULATED

Why is anhydrous ammonia regulated by OSHA's "Process Safety Management Standard," EPA's "Accidental Release Prevention Rules" and Delaware's "Regulation for the Management of Extremely Hazardous Substances?"

There are a number of technical and social factors that have led regulating agencies to take these steps. Ammonia is a toxic chemical because of its corrosive nature toward human tissue (primarily lungs, eyes and skin). It is a volatile chemical existing as a liquid only under pressure at room temperatures. Ammonia is a flammable substance in air over a small range at relatively high concentrations. Ammonia is the refrigerant of choice in large refrigeration systems because of its thermodynamic properties. Ammonia is sometimes involved in releases which cause injuries and sometimes deaths to workers, and some releases have caused precautionary evacuations of citizens beyond the facility fence line.

Ammonia has also been involved in several large transportation incidents. Ammonia is frequently reported in various databases which track the final disposition of hazardous chemicals, such as the Toxic Release Inventory (TRI), and other databases which track emergency releases of hazardous chemicals. The number and size of these releases, together with media keeping the public's eye focused on releases occurring near communities, and coupled with ammonia's hazardous properties, have created sufficient concern to have anhydrous ammonia listed as a chemical requiring prevention programs to protect citizens and workers from releases.

Table 1. Generalized 1993 TRI Emission Data For Delaware

Facility	**System Capacity**	**`93 Emissions**	**% Replacement**
A	21,807	39,980	183%
B	17,500	4280	24%
C	38,000	10,250	27%
D	17,500	21,580	123%
E	10,000	12,429	124%
F	8200	0	0%
G	10,340	10,882	105%
H	30,000	9918	33%
I	23,525	7400	32%
J	46,200	10,240	22%
K	20,000	0	0%
L	7500	6185	83%
M	6500	0	0%
N	28,597	15,095	53%
O	6106	6189	101%
P	22,618	0	0%

The objective of section 112(r) is to prevent serious chemical accidents that have the potential to affect public health and the environment. Under these requirements, industry has the obligation to prevent accidents, operate safely, and manage hazardous chemicals in a safe and responsible way. Government, the public, and many other groups also have a stake in chemical safety and must be partners with industry for accident prevention to be successful.

The risk management planning requirements of the Clean Air Act (CAA) section 112(r) complement and support the Emergency Planning and Community Right-to-Know Act of 1986. Under the new CAA requirements, you must identify and assess chemical hazards of ammonia and carry out certain activities designed to reduce the likelihood and severity of accidental releases. Information summarizing these activities will be made available to state and local governments, the public, and all other stakeholders. Using this information, citizens will have the opportunity to influence industry to reduce hazardous risks to the community.

In the broadest sense, risk management planning relates to local emergency preparedness and response, to pollution prevention at facilities, and to worker safety. In a more focussed sense, it forms just one element of an integrated approach to safety and complements existing industry codes and standards. The risk management planning requirements build on OSHA's Process Safety Management Standard.

Clean Air Act section 112(r) mandates that EPA publish rules and guidance for chemical accident prevention. These rules must include requirements for you to develop and implement risk management programs that incorporate three elements: a hazard assessment, a prevention program, and an emergency response program. These programs are to be summarized in a risk management plan (RMP) that will be made available to state and local government agencies and the public.

For purposes of this discussion, the EPA requirements will be broken down into three segments; the **Plan**, the **Program** and **Emergency Response**.

PLAN

The **Plan** is basically a paper or electronic submission that summarizes and documents activities for all covered processes. The first submission must be made by June 21, 1999 and revised at least once every five years thereafter. The **Plan** must include the following information:

Registration

This includes the site location, ownership, emergency contact information, Dun and Bradstreet Number, and the regulated substance and quantity used in the process.

Off Site Consequence Analysis

This defines the geographic area affected by a catastrophic failure of your largest vessel. EPA has provided general guidance and look-up tables as well as guidance specific to ammonia refrigeration.

Five Year Accident History

This is a summary of all accidents that have occurred over the past five years. Even though there is only a three year period between promulgation of the Rule and the compliance date, PSM has required that you assemble this information since February 1992.

Prevention Program

This is a summary of your prevention **Program.** The **Program** is essentially you PSM activities.

Emergency Response Program Summary

A summary of your emergency response written plan and methods used to notify response personnel and other appropriate authorities.

Executive Summary

This includes the highlights of the previously discussed activities and will probably be your cover sheet for the **PLAN.**

Certification

A statement that says ". . . to the best of the signer's knowledge, information and belief formed after reasonable inquiry, the information submitted is true, accurate, and complete."

PROGRAM

Compliance with OSHA PSM assures compliance with the EPA Rule. But the EPA rule extends to include a management system and emergency response. Excellent compliance guidance has been published by the International Institute of Ammonia Refrigeration (IIAR). Management systems require that a qualified person or position be assigned overall responsibilities for the development, implementation, and integration of the risk management program elements.

EMERGENCY RESPONSE PROGRAM

The emergency response program requires a written plan that contains procedures for informing the public and local emergency response agencies about releases, information about first-aid and medical treatment, procedures for use of emergency response equipment, and employee training. The National Response Team's Integrated Contingency Plan could be used here. The emergency response plan must be made available to the local emergency planning committee (LEPC) or to the local emergency response officials.

COMPLIANCE IN DELAWARE

In Delaware, ammonia refrigeration systems are used in the poultry, seafood, cold storage (of frozen foods & meat), vegetable processing, commercial ice making, orchards, and the dairy industries. The following is a description of what we found during our first inspections at these facilities.

In the newly constructed cold storage warehouses (<5 years old), design of these systems reflects state of the art control technology. Oftentimes these facilities are computer operated and capable of being remotely monitored from the refrigeration engineer's home. These facilities have been designed and constructed by reputable, knowledgeable engineering firms and these engineering firms built these facilities with good compliance with design codes. For the most part, few modifications have been made at these new facilities since start-up and the process and instrument drawings (P&IDs) only required minor updating. Most of the older food processing industries were found to lack P&IDs, the original design data, knowledge of electrical classification, ventilation design, relief valve design, and knowledge of safety systems and interlocks.

Oftentimes smaller systems and modifications to larger systems were designed, and installed by small equipment vendors who, despite good intentions, were unaware of many of the current regulations and design code specifications. These systems often required extensive modifications to brought up to current standards.

Most refrigeration facilities were found to lack written operating instructions for each individual piece of equipment in refrigeration service that address start-up, normal operation, normal shutdown, emergency shutdown, operator responses to upset conditions, and temporary operations. Oftentimes larger systems with redundant or swing compressors (in which the operating parameters are modified to fit the need) were also operated without written procedures. Some facilities had lock/tag procedures, but few other safe work practices (like hot work or opening ammonia containing equipment) were found.

It is common in the refrigeration industry to use operators to both operate the equipment and to also service or provide maintenance for the equipment in the refrigeration system. Often times these technicians have been operating refrigeration systems for many years. Some operators have taken refrigerating Engineers and Technician Association (RETA) sponsored training courses explaining general refrigeration concepts. Many have not had any formalized training, or if they did they had it more than five years ago. In larger facilities, many times the refrigeration supervisor is simply the mechanic who has been at the facility the longest and who has little formal training.

Many facilities have performed "Worker Right-to-Know" training and the operators seem to have some knowledge of the hazards of ammonia. Few facilities performed employee monitoring and know what levels of exposure to ammonia their operators are encountering while they operate the equipment. Respirators are rarely used except for escape purposes, although the odor of ammonia in the compressor rooms of many facilities is quite noticeable. Few facilities have formal written respirator programs.

Because of the situation, which we found in this industry, Delaware strongly suggests that operators who have not had formal training in the basics of refrigeration within 5 years, must pass either a home study course in basic refrigeration (such as those offered by RETA) or pass a course from a local technical college or attend and pass a course sponsored by RETA or the International Institute of Ammonia Refrigeration (IIAR). Both RETA and IIAR have substantial materials which may be incorporated into a training program.

In order to come into compliance with the Delaware Regulation, facilities must design a written training program that addresses both initial operator training and refresher training for their experienced operators. This training must address the concepts of basic refrigeration; the specific written operating instructions of the facility; emergency shutdown procedures; safe work practices; and include "on-the-job training (OJT). Verification of the effectiveness of the training must either come from written tests or on-the-job demonstrations of the specific operating tasks. Documentation of training was found to be a problem at all facilities. When inspections found that many facilities still had not met these requirements, a new compliance schedule was negotiated. Follow-up inspections have not yet been conducted.

Most of the facilities with ammonia refrigeration have minimal preventive and predictive maintenance programs. The maintenance is generally reactive, employing a fix it when it breaks attitude. Reactive maintenance allows a failure to occur. Table 1 illustrates this point. Many times the failure involves an accidental release. Preventive and predictive maintenance techniques prevent the failure, thus preventing the release.

Observation of the equipment by the operator is the primary practice. Few facilities have enough detail in their logs to allow the supervisor to make judgements regarding loss of capacity or trends. Many facilities lack work order systems and do not have detailed records of past maintenance, documentation of inspections and tests.

The following are preventive and predictive measures that can be built into a "good" refrigeration program:

Vibration testing of all rotating equipment.

Leak testing (via hand held monitors) of piping, valves and seals.

Ultrasonic thickness testing of pressure vessels and piping subject to corrosion.

Testing of compressor oil quality.

Testing of interlocks, pressure switches, temperature controls, level controls and alarms.

Infrared monitoring of electrical switch gear, and piping insulation.

Trip testing of electrical switch gear.

Testing of ammonia quality (to avoid a build up of water contamination).

Testing or replacement of pressure relief valves.

Regular internal inspections of compressors and pumps following the recommended practices of their manufacturers.

Delaware developed a generic Modification Control and Prestart-up Checklist that was given to the facilities to use in order to comply with these requirements of the regulation. There is still much confusion as to when to use the checklist, because management of change is not a normal operational philosophy of this industry. Most managers are totally unaware of why it is necessary or how to control change. In this industry, the best we seem to be able to do is to get people to go through the motions of completing the paperwork. They do not yet understand the concept.

Most facilities with refrigeration systems chose to do process hazard reviews (PHRs) using a "What If" analysis. Sometimes the list of questions generated during the first study was not comprehensive. In these cases, the study had to expanded during the revalidation of the PHR. The IIAR has published an extremely thorough "What If" checklist as part of its "Guide to the Implementation of Process Safety Management (PSM) for Ammonia Refrigeration Systems".

In many cases, we have found that facilities with ammonia refrigeration systems were lacking not only the off-site emergency response plan but also the on-site evacuation plan required by OSHA. We strongly recommend that facilities be prepared to mitigate their own releases. In Delaware, because of its reliance on voluntary fire departments, it is unreasonable to assume that someone else can or will be able to mitigate an ammonia release. When a facility is involved with mitigation of a hazardous material, it falls under the jurisdiction of OSHA's HAZWOPER regulation. This puts additional training requirements on these facilities.

Some of the larger corporations had incident investigation procedures for incidents involving injury or property loss, but nothing for accidental releases. In most cases, federal and state reporting requirements were also not recognized.

CONCLUSION

With risk management planning as the basis for accident prevention, everybody wins. You have an opportunity to demonstrate excellence in safety. Government can show effective, efficient leadership in developing sensible requirements. And communities will have a powerful right-to-know tool, as citizens work together toward reducing chemical risks to public health and the environment.

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REASONS FOR USING NUTRIENT MANAGEMENT PLANS

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Over the past decade we've been presented with phrases in the business news which are descriptive of the times. "Lean and Mean"," Down-size", "Total Quality Management", and other jargon describe concepts of improved business efficiency. Improved efficiency implies better profit and often means survival. The basic concept is to reduce or control input and thereby reduce input cost while maintaining or increasing output so that there are more dollars left for profit. In agriculture, nutrient management is a technique for improving efficiency which can improve profit.

Over the past several decades we have all been involved with environmental issues from a variety of positions, pro or con. Few of us express a disregard for the environment but we do have different attitudes as to the magnitude of our impact or how to mediate that impact. In simple terms, air, soil and water pollution are a result of too much of something in the wrong place. The basic mediation concept is to reduce or control input while maintaining or increasing output so that there is less unused residual to accumulate in the environment (i.e., increased efficiency). In agriculture, nutrient management is a technique for improving efficiency which can improve environment.

As some would say, nutrient management is a "win/win" situation. But some do not see the profit, while others fail to see the environmental impact. I suggest that they have not looked far enough. In both the business and environmental sense we too often observe only a small part of the entire system because that is where we stop individual ownership. We may manipulate some part while ignoring the effect of the activity on other parts. For example, we measure the feed conversion of an animal by mass of input as compared to harvested animal mass without a measure of the quantity or quality of residuals (manure and processing waste). Yet, residuals may have significant impact on profit when we factor the cost associated with whatever happens to those residuals.

The original concept of nutrient management on farms is focused on how much animal manure and fertilizer should be used on what crops. The intent is to maximize the utilization of residual nutrients from animal agriculture at the source of production. For reasons of efficiency, animal enterprises are increasingly being concentrated both on the farm and within geographic regions. Some farms or regions do not have the land or crop base to utilize all of the residual nutrients produced. Residual nutrients must then be redistributed for dilution in the environment. Nutrient management must be expanded to include development of treatment methods which allow the residuals to be useful to other farms or businesses. The cost associated with residual treatment must be borne by the expanded animal enterprise and must be considered in the profitability of expansion. Whole farm and industry planning for profitability requires a nutrient budget which includes all forms of nutrients entering and leaving.

While this session is devoted to descriptions of nutrient management programs on farms, it must be realized that nutrient management is also an industry-wide, regional, national and world-wide concept. There is and will continue to be an increasing demand and opportunity for the development of technologies and services that reduce nutrient input and provide value-added residuals for recycling and reuse in agriculture and other industries. However, the major use of farm residual nutrients will remain on the farm and those nutrients must be used wisely if the farm is to survive. It is therefore necessary that farms adopt nutrient management planning techniques.

ANIMAL WASTE EDUCATION PROGRAMS IN ARKANSAS

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The Arkansas livestock and poultry waste management program that is now in effect can serve as a model for many states. Arkansas was forced to move ahead in the development of a program that was initially controversial and intensely disliked by some who had to make the greatest adjustment. However, it is now accepted as a necessary environmental program by the majority of growers and industry representatives as well as educators and regulatory personnel.

Arkansas Waste Management Education is divided into two programs:

The liquid animal waste program - If water is added to manage manure or if rainfall is allowed to dilute it creating liquid runoff, then a tank, holding pond, or lagoon is required and a permit with management plan must be in force. This mandatory program is outlined in the Arkansas Department of Pollution Control and Ecology's (DPC&E), "Regulation 5", which was ahead of and in full compliance with EPA's CAFO permits. Arkansas is the only state in EPA region 6 that issues NPDES permits on it's own authority and has done so for about 25 years. All of the state's 400 swine farms, about 100 of it's 750 dairies (with more to be added), and less than 100 commercial table-egg farms have liquid permits.

The dry animal waste program - If manure (litter) can be maintained in a relatively dry condition such that no runoff occurs, then voluntary best management practices can be adopted by growers and the liquid permit process can be avoided. This requires that manure be spread at a "legal" rate (based on nutrient content) immediately upon removal from a confinement area, or a dry-stack shed be available so the manure can be stockpiled until disposition. This voluntary program is targeted primarily toward the broiler industry, but also covers about half of the states dairies and virtually all beef cattle operations. Arkansas has few if any confinement cattle feeding operations.

Program Initiation

Former Governor Clinton appointed an Animal Waste Management Taskforce in 1990 in response to an increase in commercial swine production in the state, and unfounded national media reports about dead chickens clogging the pristine waterways of Northwest Arkansas. The taskforce consisted of representatives from state and federal agencies and industry personnel. They met for almost two years with the result being mandatory regulations for growers with liquid animal waste and a trial effort for voluntary adoption of best management practices (BMPs) for growers with dry animal waste which includes broiler litter.

The Education Effort

Growers with liquid permits are required to attend four hours of annual training on waste management practices. New permit holders are required to receive four hours of individual training the first year the permit is in force, and then attend annual training thereafter. The Cooperative Extnesion Service (CES) was named the lead agency to coordinate this effort. Arkansas CES has worked very closely with NRCS on this program, and both groups recognized the necessity of putting together a coalition of all involved state and federal agencies and industry representatives to support this effort.

Growers with dry manure are not required to attend training, but are presented with frequent opportunities to attend meetings on best management practices. These are normally incorporated with producer meetings, and the meetings are designed for target audiences; poultry, dairy, beef. Attendance is good for several reasons:

> The blend of environmental programming with production programming makes the meetings more attractive to growers. While they recognize the importance of environmental stewardship, growers are primarily interested in learning to be better managers and how to make more money.
>
> The meetings are strongly supported by the industry, because without progress and voluntary adoption regluations are sure to come.
>
> Even though the voluntary progrm is not regulated, growers still have a legal obligation not to

pollute. Arkansas DPC&E has general regulations that basically prohibit water pollution from any source, so growers recognize the need to understand laws and regulations.

In-service training is provided (as budgets permit) to bring in all involved agency personnel for group training. This insures that everyone is familiar with all programs that are in place, and that field personnel from different agencies have the same interpretation of BMP's to present a united front with growers.

Special meetings are also provided as requested by industry. One such series of meetings was developed for poultry field representatives. This was requested by the Arkansas Poultry Federation, and was attended jointly by fieldmen from competing companies.

Special efforts have been made to introduce DPC&E inspectors to new programs as they have been implemented (such as whole hog composting), so they will know what to expect when they see these the first time in the field.

The Conservation Partnership

The program effort in Arkansas is supported by the cooperative efforts of swine, poultry, and dairy industry representatives along with the following agencies:

University of Arkanasa, Research and Extension
National Resources Conservation Commission
Arkansas Soil and Water Conservation Commission
The Conservation Districts
Arkansas Department of Pollution Control and Ecology
Farm Service Agency (FSA)
Arkansas Health Department
Environment Protection Agency
Livestock and Poultry Industry Representatives

The lead agency for coordination of education programs is the Cooperative Extension Service which is workable only with the close cooperation of NRCS. For a waste management program to be truly successful and progress beyond the early milestones, it is mandatory that CES and NRCS work together very closely. They must support the same efforts, even though each group has a different role to play, and they must present a consolidated front at the country and farm level. It has also been important in Arkansas to work closely with the Soil and Water Conservation Commission. They have been designated as the lead agency for state water quality work, and they continue to administer 317h funds in Arkansas. They have also developed a staff of competent professionals in water quality and environmental work.

Obviously, the group requires input and support from EPA, programs must be coordinated with FAS for cost share, and in Arkansas, the State Health Department inspects and approves construciton of Dairies. The beef industry has not been significantly involved, because there are few if any confined beef feeding operations in the state.

Funding

A limited program can be initiated within the base funds of the participating organizaiton. However, in CES the best opportunity for program development has been through grant programs that allow staff expansion and dedicated positions to waste management education work. In Arkansas, one Agricultural Engineer, one Environmental Specialist, and one technician were added for waste management work. Primary funding sources have been Federal Extension Water Quality Funds and EPA 319h funds. Grants usually include demonstration projects, some monitoring work, publications, technology transfer meetings, and reporting obligations.

RESULTS

All growers with liquid waste permits, and all involved governmental agency personnel have now received their fourth year of training on liquid animal waste BMPs and related production practices. Broiler and dairy producers have had four years of county based training on voluntary BMP implementation and the importance of developing whole farm management plans for manure management. Waste management violations have decreased consistently during this period, even though there has been an increase in the number of farms and an increase effort in DPC&E inspections.

OBSERVATIONS

There must be an effective partnership with all involved players, including industry and grower representation for an animal waste program to succeed. There must be a blend of Scientists, environmentalists, and common sense agriculturists in the program planning sessions. In-service training for all agency personnel together is very helpful in developing a coordinated program. Each agency as well as industry should particpate in the program presentation, so ownership can be claimed by all.

Participating personnel from your states pollution authority must be involved in the animal waste program. Nurture a relationship within that agency with personnel who have authority and wisdom. It may be necessary to visit farms with them and educate them about confined animal produciton. Volunteer to present programs to your state's inspection officers, so they will fully understand what may be acceptable or unacceptable. In many situations, a small collection of animal manure looks a lot worse than any enviornment threat that it may present.

When CES and NRCS are together on an issue, they are normally correct in their assessment of the situation. Other groups will usually listen to well founded recommendations.

NUTRIENT MANAGEMENT PROGRAMS AND TRAINING IN NMP AND ENVIRONMENTAL COMPLIANCE PROGRAMS: GEORGIA PROGRAMS

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Nutrient Management Programs (NMP's) are coordinated by the Water Quality Coordinator of the Cooperative Extension Service (CES). The program focus is to educate livestock producers, poultry, dairy , swine and beef cattle, on the economic benefits of using the nutrients in animal wastes efficiently. By emphasizing the economic benefits, the animal wastes would be efficiently used; therefore, preventing water quality problems.

The nutrient management plan (NMP) recommendations were developed in coordination with the National Resource Conservation Service (NRCS), formerly the Soil Conservation Service (SCS), so that programs delivered by either the CES or the NRCS would be the same. County agents were trained on proper methods of non-point sources (NPS), so that they could assist livestock producers on a one-to-one basis of developing NMPs. Nutrient Management Plan training is also offered to management and field service personnel of poultry companies so that they can also assist growers with proper animal waste handling techniques.

At the present time, the water quality in Georgia is good and there is no pending legislation in Georgia to place more stringent requirements on control of animal waste application. To assist the Environmental Protection Division (EPD) of the Georgia Department of Natural Resources (DNR) the water quality coordinator serves as the liaison contact with the EPD.

The Georgia EPD feels that animal wastes do not significantly impact the ground water quality in Georgia. Extensive well testing has shown that only 6 percent of wells associated with animal production units exceed 10 mg/L of (N-NO3). Inspection of wells where water has exceeded 10 mg/L (N-NO3) has shown poor well construction to be the cause rather than contamination of the aquifer. Proper sealing and grouting of wells to prevent surface water from entering the well at the casing has been effective in solving the high nitrate well problem.

In 1995, a tour for animal producers, county agents and other governmental personnel was conducted to the Lake Okeechobee, Florida area, to make the tour participants aware of the economic impact that can occur when the application of animal wastes is regulated. A current water quality problem that is being addressed by the water quality coordinator is the one of salt water intrusion into a coastal aquifer (Floridan). The Georgia EPD proposed that no new wells or increased pumping would be allowed from the aquifer after July 1, 1996. The effect would be to prevent growth of irrigated crops or to prevent increased water use by processing. The proposal has been modified temporarily because there was not good data on quantities of water utilized by irrigated agriculture. The proposed limitation of water extraction from the Floridan aquifer came as a surprise to Georgians. Limited water supplies were associated with the dry western states not with the high rainfall areas such as coastal Georgia.

In summary, the Georgia NMP program is one based on education and voluntary adoption of best management practices. At the present time, this approach is felt to be an acceptable method of efficiently utilizing the plant nutrients from animal wastes, while at the same time protecting the quality of Georgia's water.

THE MARYLAND NUTRIENT MANAGEMENT PROGRAM

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The Maryland Nutrient Management Program (MNMP) was started in 1989 to encourage nutrient management planning by agricultural producers. Nutrient management planning is a series of best management practices (BMPs) aimed at reducing agricultural nonpoint source pollution by balancing nutrient inputs with crop nutrient requirements. Such planning can enhance farm profitability while simultaneously protecting water quality. Nutrient management planning includes soil testing, analysis of organic nutrient sources, utilization of organic sources based on their nutrient content, estimation of realistic yield goals, nutrient recommendations based on soil test levels and yield goals and optimal timing and method of nutrient applications. MNMP is a component of Maryland's response to the Chesapeake Bay Agreement of 1987 which committed Maryland, Virginia, Pennsylvania and the District of Columbia to a 40% nutrient reduction goal by the year 2000.

In 1989, Maryland Department of Agriculture (MDA) hired a program director for the MNMP and, via a memorandum of understanding (MOU) with the University of Maryland Cooperative Extension Service (UMCES) and its accompanying financial support, enabled UMCES to provide additional staff for enhanced nutrient management efforts. Initially, UMCES staff included a program coordinator and 14 nutrient management consultants. These consultants were placed in 14 of Maryland's 23 counties where animal production was most intense. From 1989 until 1992, only plans developed by UMCES nutrient management consultants were counted by MDA toward planning goals.

In 1992, legislation enabled the certification of industry (private-sector) nutrient management consultants. This group includes fertilizer dealers, sludge contractors, independent crop consultants and farmers. Nutrient management planning progress has been greatly enhanced by the inclusion on these individuals as providers of state-approved nutrient management plans.

ORGANIZATION OF PROGRAM

The MNMP is a coordinated effort between MDA, UMCES and private industry, each with specific roles and responsibilities.

Roles and Responsibilities of MDA

The MNMP is administered by MDA, which is responsible to the governor for meeting the goals of the Chesapeake Bay Agreement as they relate to agriculture. MDA coordinates continued discussions on proposed changes in the nutrient management regulations and chairs the nutrient management advisory committee, represents Maryland on regional Chesapeake Bay committees and workgroups, coordinates training for nutrient management consultants, administers the nutrient management certification examination, inspects plans of certified nutrient management consultants for compliance with regulations, issues nutrient management certificates and licenses and administers the funding of the UMCES Nutrient Management Program.

Role and Responsibilities of Industry Nutrient Management Consultants

Industry nutrient management consultants provide nutrient management planning services for their clientele, report planning progress annually to MDA and provide representation on the Nutrient Management Advisory Committee.

Role of UMCES in Nutrient Management Planning

Under a MOU with MDA, the UMCES Nutrient Management Program provides nutrient management planning services to Maryland producers via consultants located in most county Extension offices. In addition, UMCES Nutrient Management Program participates in research efforts to improve nutrient management practices, provides formal training and ongoing support for nutrient management consultants, coordinates the evolution of the nutrient recommendation software, supports personnel in soil testing laboratory for manure analysis (thus enabling agricultural producers to obtain "free" analysis of manure and other organic nutrient sources), tracks nutrient management planning progress, and produces educational materials on subjects relating to nutrient management.

UMCES consultants provide nutrient management planning services to clients following a priority agreed to in the MOU between MDA and UMCES. The priorities are as follows: (1) producers with pollution problems identified by enforcement actions or local knowledge; (2) producers requiring plans for discharge permits; (3) producers requiring new or updated plans for cost-shared structures, such as animal waste management systems and dead bird composters; (4) producers with large livestock operations; (5) producers in priority watersheds; (6) producers targeted for implementation of the tributary strategies program; (7) producers in the Chesapeake Bay critical area; (8) producers with limited resources and (9) producers who have previously participated in the program who request continued assistance.

The primary focus of the UMCES effort is the development of nutrient management plans. Nutrient management plans are documents which incorporate soil test results, realistic yield goals and estimates of residual nitrogen to generate field-by-field nutrient recommendations. In addition, information and assistance with a variety of related activities is also provided, such as soil and manure sampling, record keeping, yield checks, calibration of nutrient application equipment and the pre-sidedress nitrate test (PSNT).

Communication between Extension and industry nutrient management consultants about prospective clientele is encouraged to minimize the perception of competition.

MARYLAND'S LAW AND ITS VOLUNTARY PROGRAM

The Maryland Nutrient Management Certification and Licensing Law became effective in October 1992. It established the definitions of nutrient management plans and certified nutrient management consultants (CNMCs), established the requirements for certification and licensing of CNMCs, established a fee schedule for certification and licensing and authorized MDA to develop regulations and establish a Nutrient Management Advisory Committee (NMAC).

The NMAC consists of representatives from industry, the environmental community, academia and governmental agencies. MDA consulted with the NMAC in the development of regulations which prescribe the requirements for a state-approved nutrient management plan, educational requirements for CNMCs, and other related issues. The NMAC continues to meet on an as-needed basis to advise MDA.

CNMCs, who must demonstrate a combination of background and knowledge acceptable to MDA and obtain an acceptable grade on the certification exam, are required to hold a license or be employed by an licensed individual or firm. Licensed firms and individuals are required to report their planning progress annually. Planning progress consists of the number of nutrient management plans developed and the acreage for which such plans were provided, summarized by crop, watershed and county. There is no requirement that a license holder develop nutrient management plans, as long as such non-activity is reported.

With a few exceptions, Maryland's nutrient management program is voluntary for Maryland's agricultural producers. State-approved nutrient management plans are, however, required in several instances. Producers applying for state cost-share funds for the construction of manure storage facilities and poultry mortality composters, animal producers requiring NPDES permits and landowners wishing to place their property in an agricultural preservation program are required to have nutrient management plans.

PROGRESS

MDA has administered the nutrient management certification examination twice yearly since January 1993. Three hundred and forty-seven individuals were certified as of June 1996. Two hundred and twenty-five individuals are Maryland residents. One hundred twenty-two residents of other states (Pennsylvania, Delaware, Virginia, West Virginia, New Jersey, and the District of Columbia) were certified by Maryland as nutrient management consultants. A reciprocal arrangement for nutrient management certification among signatory state to the Chesapeake Bay Agreement has recently been promulgated.

MDA has organized seven 2-day training sessions for individuals preparing for the certification examination ("Fundamentals of Nutrient Management") and eleven 1-day continuing education sessions for CNMCs. Topics for the continuing education sessions included "Managing Nitrogen", "Efficient Land Application of Biosolids", "Phosphorus", "Enhanced Nutrient Management Planning", "Hydrology and its Influence on Plant Nutrient Movement" and "Micronutrients, Potassium and Lime". Eight intensive half-day regional workshops were held to familiarize CNMCs with the development of nutrient management plans.

CNMCs have developed nutrient management plans for more than 750,000 acres of pasture and cropland since the inception of the MNMP. This effort represents tremendous progress toward the goal 1.25 million acres by the year 2000. Since 1994, the first full year that industry CNMCs provided state-approved nutrient management plans, planning progress has exceeded 200,000 acres a year (Table 1).

TABLE 1. New acreage for which state-approved nutrient management plans were provided (1989-1995)

Year	Acres
1989	250
1990	42,950
1991	69,100
1992	64,850
1993	122,650
1994	212,200
1995	224,000
Total	736,000
Goal	1,250,000

INCENTIVES FOR AGRICULTURAL PRODUCERS' PARTICIPATION

Agricultural producers who are managing their nutrient resources sub-optimally can realize considerable financial rewards by following a state-approved nutrient management plan. Monetary and nutrient savings are most often observed from soil testing, recognizing the nutrient value of manures and composts, crediting nitrogen from legumes in a rotation and previously-applied manures and setting realistic yield goals.

Many agricultural producers in Maryland are excellent "nutrient managers". Nonetheless, all agricultural producers are encouraged to develop or have developed for them a state-approved nutrient management plan. Development of a nutrient management plan can assist producers in fine-tuning their nutrient management practices and documents the willingness of agricultural producers to participate in "cleaning up the Bay".

NUTRIENTS: CROP UPTAKE, SOIL RESERVE AND MINERALIZATION RATES

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Under normal conditions, nitrogen, phosphorus, and potassium will move through cycles on a farm. They will go from a feed crop, to the animals, back to the soil as manure and crop residues, and finally on to another crop. As nutrients move through the farm system they undergo biochemical processes which affect their retention, use and loss. When the cycles are disturbed, the nutrients may be lost from the system. Understanding these nutrient cycles is critical for understanding the behavior and management of nutrients for maximum agronomic and economic impact and minimum environmental impact.

NITROGEN

Nitrogen is the nutrient that is most often the limiting factor in crop production. Crops require a relatively large amount of nitrogen to achieve optimum yields. Examples of the amount of nitrogen removed from the soil by common agronomic crops are shown in Table 1. This nitrogen can be supplied by mineralization of soil organic matter, by fertilizer nitrogen, by manures, or other N containing waste materials. Also, crops like alfalfa, clover, and soybeans are legumes which means they have formed a symbiotic relationship with rhizobia bacteria in nodules on their roots that enables them to get the nitrogen that they need from the atmosphere. These legume crops do not need supplemental nitrogen to meet the crop demand. However, they will utilize applied nitrogen.

Of the three nutrients, nitrogen has the most complex behavior. Nitrogen makes up almost 80% of air, but that nitrogen may be used by the plant only after it is converted to available forms industrially or by rhizobia in association with legumes. The total amount of nitrogen in the soil is large. In Pennsylvania, soil nitrogen averages about 0.14% or about 2,700 lb/acre. Most of this (approximately 98%) is found in the soil organic matter. Organic nitrogen because of its chemical composition is unavailable for plant uptake. Only when converted to mineral forms by soil microbes does the nitrogen in organic matter become available. The mineral forms of nitrogen that are available for plant uptake are ammonium (NH_4^+) and nitrate (NO_3^-).

In the soil, nitrogen is vulnerable to a complex variety of process brought about by the interactive effects of weather and soil microbes. These processes may increase availability of nitrogen and/or increase the potential for loss of the nitrogen to the environment. A diagram summarizing nitrogen behavior is pictured in Figure 1.

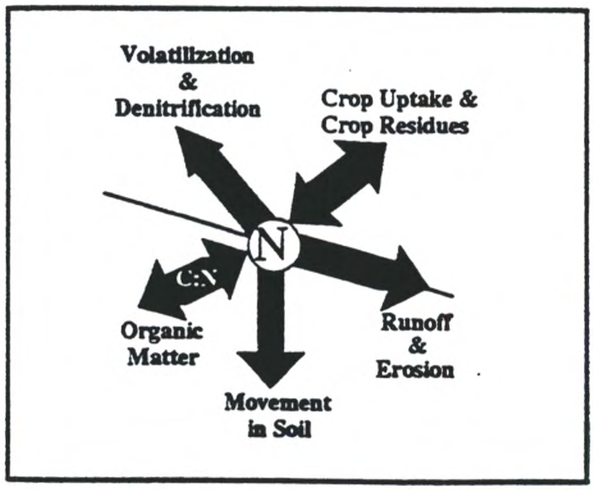

Figure 1. Summary of nitrogen behavior in soil.

In soil, organic nitrogen either from soil organic matter or from manure is broken down, or mineralized, by microbes into ammonium nitrogen, the form of nitrogen contained in ammonium fertilizers. In poultry manure 25 to 50% of the nitrogen is in the organic form and thus must be mineralized before it becomes available. The remainder of the nitrogen is in the urea or uric acid forms which readily convert to mineral, ammonium nitrogen in the soil. Ammonium nitrogen may be retained in the soil as an exchangeable cation and taken up by crops. Organic nitrogen and ammonium nitrogen are both relatively immobile compounds, but they can be lost when soil is eroded.

Ammonium nitrogen can also be converted to ammonia gas (NH_3) and lost to the atmosphere by volatilization if this reaction occurs on the soil surface. This process occurs readily with urea nitrogen either from fertilizer or manure. If the urea fertilizer or the manure is incorporated by tillage or

TABLE 1. Typical crop nutrient removal

Crop (units)	Per unit of yield N	P_2O_5	K_2O	Removal for given yield Yield/A[f]		N	P_2O_5	K_2O
Corn (bu)	0.75	0.4	0.3	125	(bu)	95	50	40
Corn silage (T)[d]	9.0	5.0	11.0	21	(T)	190	105	230
Grain sorghum (bu)	0.5	0.6	0.8	125	(bu)	65	75	100
Forage sorghum (T)[d]	9.0	3.0	10.0	15	(T)	135	45	150
Sorghum/sudangrass4	8.0	7.0	7.0	15	(T)	120	105	105
Alfalfa (T)[b,e]	50.0[a]	15.0	50.0	5	(T)	250	75	250
Red clover (T)[b,e]	40.0[a]	15.0	40.0	3.5	(T)	140	55	140
Trefoil (T)[b,e]	50.0[a]	15.0	40.0	3.5	(T)	175	55	140
Cool-season grass (T)[b,e]	40.0	15.0	50.0	4	(T)	150	60	200
Bluegrass (T)[b,e]	30.0	10.0	30.0	2.5	(T)	75	25	75
Wheat/rye (bu)[c]	1.5	1.0	1.8	60	(bu)	90	60	110
Oats (bu)[c]	1.1	0.9	1.5	80	(bu)	90	70	120
Barley (bu)[c]	1.4	0.6	1.5	75	(bu)	105	45	110
Soybeans (bu)	3.2[1]	1.0	1.4	40	(bu)	150	40	56
Small grain silage (T)[d]	17.0	7.0	26.0	6	(T)	100	40	160

[a]Legumes fix all of their required nitrogen. However, they also are able to use nitrogen as indicated.
[b]For legume-grass mixtures, use the predominant species in the mixture.
[c]Includes straw.
[d]65% moisture.
[e]10% moisture.
[f]Typical yield, for example only. Actual yield will vary considerably.

rainfall immediately after application, the loss of nitrogen by volatilization is minimized.

Soil bacteria can also convert the ammonium nitrogen to nitrate nitrogen. This is the major form of nitrogen taken up by plants. Because nitrates are readily dissolved in water and are not adsorbed to the soil, they can be easily lost to surface or groundwater. This loss is called leaching and is most likely to occur in well-drained soils. It is a significant source of surface and groundwater pollution.

Nitrates can be changed to nitrogen gases (N_2 and N_2O). This process, called denitrification, occurs when oxygen is limited in soils because they are saturated with water. Denitrification is caused by anaerobic microbes that, in this situation, use the oxygen present in nitrate (NO_3^-) In the process, they convert the nitrate nitrogen into nitrogen gases that are lost to the atmosphere. Manure provides an excellent energy and nitrate source for the microbes, and denitrification occurs rapidly soon after soil is saturated with water and normal oxygen is no longer available to the microbes. Denitrification is most common in heavy, poorly drained soils, but will occur in any soil that becomes saturated with water.

Like higher plants microbes require nitrogen for growth, thus they compete with plants for the supply of mineral nitrogen in the soil. In this process, called immobilization, nitrogen is assimilated into soil organic matter by the microbes. This process is the opposite to mineralization. The amount of immobilization that occurs depends on the relative amount of energy and nitrogen available to the microbes. If there is a large amount of energy in the form of organic carbon available in the soil, microbial populations will increase and so will the demand for nitrogen. This process is especially important when an organic material is added to the soil. If the added material has a relatively low amount of carbon relative to its nitrogen content (a low carbon to nitrogen ratio), the microbes will be able to get adequate nitrogen to meet their demands as they breakdown the carbon. However, if the added material has a high amount of carbon relative to its nitrogen content (a high carbon to nitrogen ratio), there will not be enough nitrogen from the material to support the microbes. In this situation the microbes will utilize mineral nitrogen already in the soil and thus compete with the crop for the available nitrogen. If a large amount of high carbon, low nitrogen material is added to a soil this can result in a severe nitrogen deficiency in the crop.

Generally materials with a carbon to nitrogen ratio (C:N) less than 20 will result in a net mineralization or release of mineral nitrogen. Materials with a C:N ratio greater than 30 will usually result in net immobilization or tie-up of nitrogen. Between 20 and 30 there will be little net change in mineral nitrogen in the soil. Examples of typical carbon to nitrogen ratios are given in Table 2. Note from Table 2 that manure itself has a relatively low C:N ratio and thus should result in release of available N. Nitrogen tie-up by immobilization is a temporary process because as the carbon source is depleted the microbes will die and the nitrogen they have assimilated will be released in mineral form and become available in time for most crops to effectively utilize it. A common practical concern with immobilization is the effect of litter in the manure. Note that most of the materials commonly used for litter have a high C:N ratio. In most cases this is not a significant problem because the amount of litter is small compared to the amount of manure and thus the C:N ratio of the combined manure and litter will be relatively low. In some cases where there is excess mineral nitrogen in the soil, high rates of a high C:N ratio material have been added to sequester some of this excess nitrogen and then release it slowly over time to improve the utilization of the nitrogen by plants. This technique should only be considered in a remedial program to deal with a high nitrogen situation.

Because of the temporary nature of the immobilization, it should not be considered as a management option to allow excess nitrogen to be applied in the first place.

TABLE 2. Typical carbon to nitrogen ratios for some common organic materials

Source	C:N Ratio
Soil	10:1
Fresh legume residue	15:1
Manure	20:1
Fresh non-legume residue	30:1
Corn stover	60:1
Straw	80:1
Sawdust	>200:1

Since most of the reactions of nitrogen in the soil are microbial they are very sensitive to environmental conditions such as moisture and temperature, ie. the weather. Under saturated or air dry conditions most microbial activity is limited. Likewise at temperatures below 50°F or above 100°F activity is also limited. Our inability to predict the weather is a major factor in our difficulties in predicting N behavior in the soil and thus making N management recommendations and determinations about the fate of nitrogen.

Poultry manure is a major source of nitrogen. Typical figures for nitrogen content of poultry manure determined from Pennsylvania poultry farms are given in Table 3. Release of nitrogen from manure for plant uptake and/or loss to the environment can be estimated from a knowledge of the relative amount of organic and inorganic nitrogen in the manure, whether the manure will be incorporated or not and the anticipated mineralization from the organic N in the manure. An example of the process for making this estimate is given in Figure 2. This figure is for Pennsylvania conditions. The availability factors may vary in other areas. Check with local sources for the availability factors for your area. In this method, the amount of ammonium nitrogen and organic nitrogen in the manure is determined from the manure analysis. The availability of the ammonium nitrogen is adjusted for the anticipated volatilization losses based on the time until the manure is incorporated. The release of organic nitrogen is estimated from mineralization factors for the current year and any residual from previous manure applications.

TABLE 3. Typical poultry manure analysis

Poultry Type	% Dry Matter	N	P_2O_5 (lb/T)	K_2O
Layer	40	37	56	32
Pullet	35	43	46	25
Broiler	70	73	63	46
Turkey (tom)	60	52	76	42
Turkey (hen)	65	73	88	46

Note: When possible, have manure analyzed. Actual values may vary over 100% from avarages in the table.

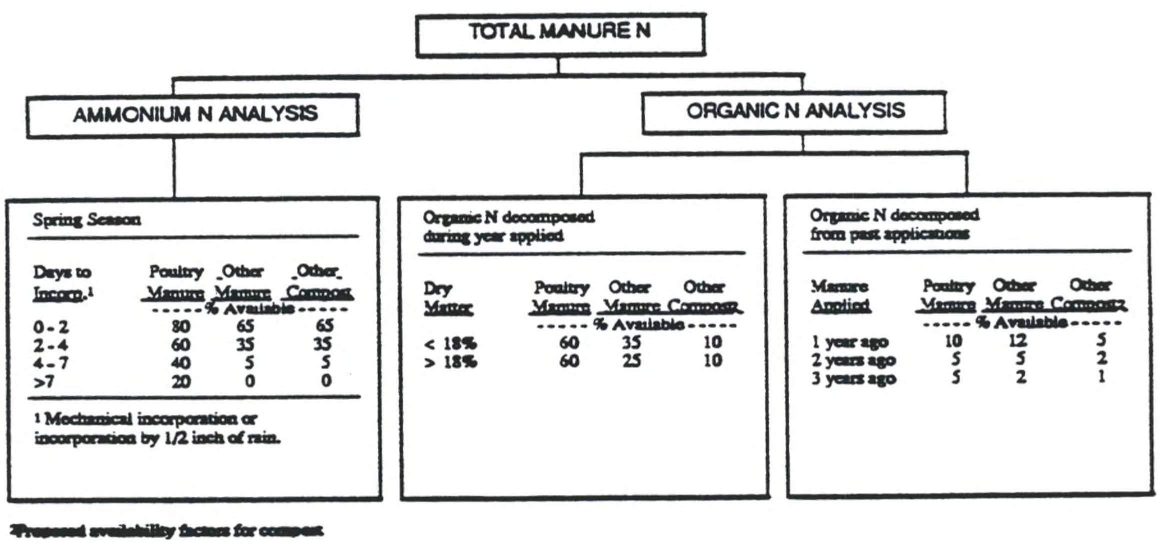

Figure 2. Example method for estimating availability of nitrogen from manure.

PHOSPHORUS

Phosphorus (P) is also a macro nutrient but generally smaller amount of phosphorus are required than nitrogen. Typical amounts of phosphorus removed from soil by crop uptake are given in Table 1.

The general behavior of phosphorus is illustrated in Figure 3. In the soil, phosphorus is the least mobile of the macro nutrients. Especially under very acidic or very alkaline conditions, phosphorus may become fixed in insoluble compounds with iron, aluminum or calcium. This fixation reduces the amount of phosphorus available to plants and also allows phosphorus to build up in the soil. This buildup could have detrimental effects on plant growth such as phosphorus induced zinc deficiency. Fortunately, this is rarely a problem in soils where the high levels of phosphorus come from manure because the manure also supplies zinc. Where high levels of phosphorus come strictly from fertilizer however this can be a serious problem. Soil pH is an important management factor for phosphorus availability to crops. Maintaining soil pH between 6 and 7 will usually result in optimum phosphorus availability.

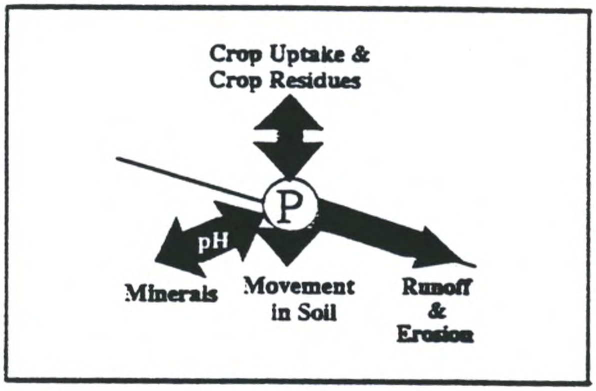

Figure 3. Summary of phosphorus behavior in soil.

Because the soluble forms of phosphorus are rapidly converted to insoluble forms, phosphorus is not generally leached from the soil. However, phosphorus, especially in soils with high phosphorus levels or freshly fertilized or manured soils, particularly on steep slopes, may be lost due to erosion and runoff. The phosphorus carried into surface waters attached to soil that is eroded can eventually dissolve and become a significant source of water pollution. Properly designed, installed and maintained soil and water conservation practices are critical for minimizing phosphorus losses associated with erosion. Although phosphorus is not very soluble, when it is present at high levels in the soil, especially at the surface where it is in contact with runoff water, loss of soluble phosphorous is possible. Thus phosphorus loss can occur even if there is little or no erosion. The main characteristics of a site that should be evaluated to determine the potential for phosphorus loss include: soil erosion of the site, water runoff at the site, soil test P level, P fertilizer rate and method of fertilizer application, organic P application rate, method of application and proximity to a vulnerable water body. All of these factors must be integrated to evaluate a site for phosphorus loss. For example, a higher soil test level or application rate of phosphorus could likely be tolerated with little potential for loss on a site with little erosion or runoff. Conversely, on a site with a high erosion and/or runoff potential, extreme care would be required in planning and implementing phosphorus applications.

Poultry manure is a significant source of phosphorus (Table 3). While manure phosphorus is mostly in the inorganic form, a significant amount may occur in organic compounds. These compounds must be mineralized for the phosphorus to be available for crop uptake. However, the organic phosphorus in manure is somewhat protected from fixation into unavailable forms. The net result is that even though some of it must be mineralized before it is available, the phosphorus in manure is similar in availability to phosphorus in fertilizer. Thus roughly equal results over a growing season can be obtained with the application of the an equal amount of phosphorus from either fertilizer or manure. Where appropriate, a starter fertilizer should still be used even if the manure application is supplying adequate phosphorus to meet crop needs.

POTASSIUM

Potassium (K) is required by plants in amounts similar to nitrogen (Table 1). Note that most of the potassium is found in the vegetative parts of crops rather than in the grain. Thus the method of harvest has a major impact on the amount of potassium that is removed from the soil. This can be seen clearly by comparing the potassium removal from a 125 bu/acre corn grain crop (40 lb K_2O/acre) with the removal by an equivalent crop of 21 ton/acre corn silage crop (230 lb K_2O/acre) as shown in Table 1.

The general behavior of potassium is illustrated in figure 4. Potassium is intermediate in mobility among the macro nutrients. Being a cation in the soil, potassium is held in available form on the soil cation exchange capacity (CEC). Thus, it accumulates in the soil, which is generally desirable because it helps supply plant needs. Like phosphorus, however, potassium can accumulate to excessive levels and have detrimental effects on plant growth. Small amounts of potassium may be leached from soil, especially sandy soil, but it is not considered a pollution problem. The main loss mechanism for potassium is through soil erosion. As the soil clay, which is the site of the soil CEC, is eroded away the potassium is lost with the sediment.

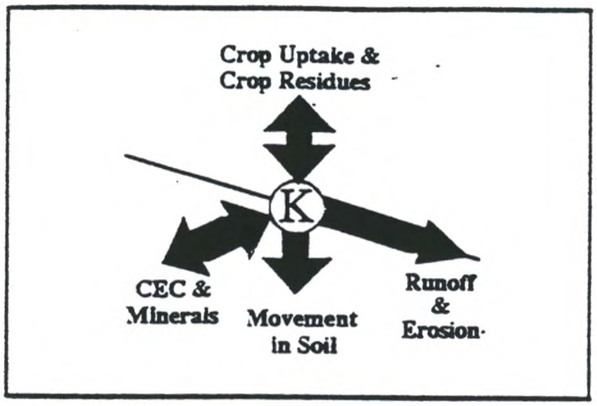

Figure 4. Summary of potassium behavior in soil.

Typical potassium content of poultry manure is given in Table 3. Potassium in manure is mostly in the soluble form and thus does not require mineralization to become available to crops. For practical purposes manure potassium can be considered equivalent to fertilizer potassium for meeting crop needs.

NUTRIENT MANAGEMENT IN CROPPING SYSTEMS

In general, if manure is applied to meet the nitrogen needs of a continuous grain crop, phosphorus and potassium will likely be applied in excess of crop needs and eventually build up to excessive levels in the soil. Forage crops, to which manure is not applied, planted in rotation with grain crops receiving manure will help remove the excess phosphorus and potassium and keep the three nutrients in balance over the rotation. This is illustrated in Figure 5. In each example in Figure 5 manure was applied to totally meet the nitrogen needs of the corn crop. With continuous corn (Figure 5a), note the large excess of phosphorus and potassium that are applied. In the rotation example (Figure 5b), when manure is applied to meet the nitrogen needs of the corn, the unmanured forage crop in the rotation uses the excess phosphorus and potassium and some fertilizer phosphorus and potassium will probably be required to meet the needs of the forage crop. This effect will vary with different rotations but the concept will be the same. Regular soil testing is helpful to monitor the balance of phosphorus and potassium over the crop rotation.

In monoculture where it is necessary to apply manure on a continuous basis, phosphorus and potassium levels can be expected to increase if the manure is applied to meet the nitrogen needs of the corn as was illustrated in Figure 5a. To avoid this buildup of phosphorus in the soil, manure rates

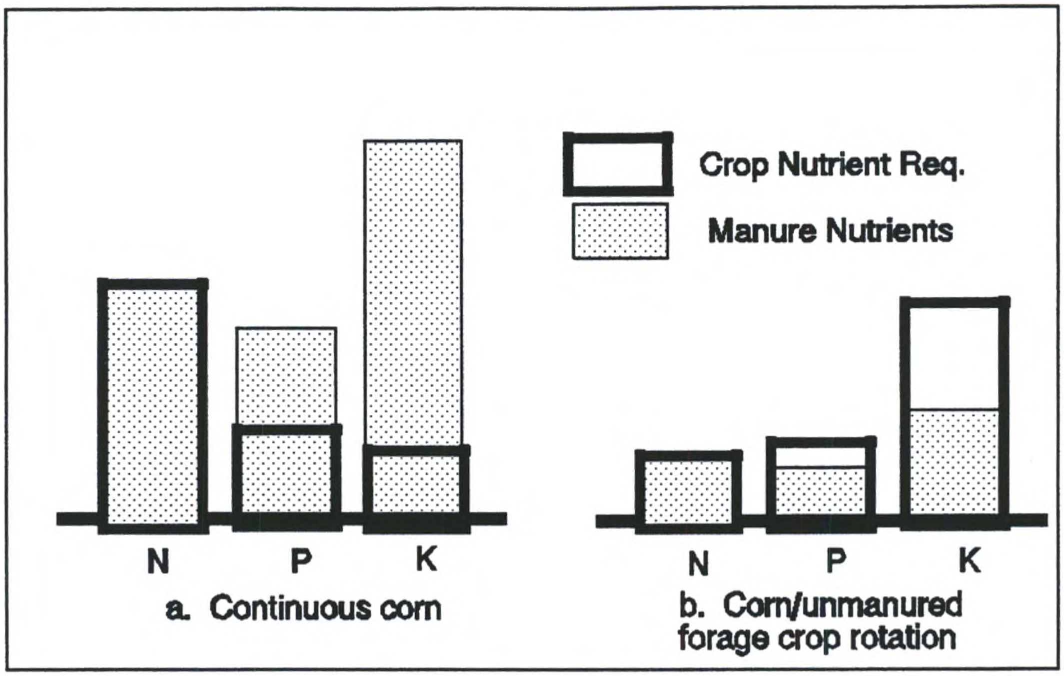

Figure 5. Crop nutrient requirement vs. manure nutrients for continous corn and for a corn/unmanured forage crop rotation.

can be based on not exceeding the crop removal of phosphorus as given in Table 1. The balance of nutrients for poultry manure applied to corn based on balancing the phosphorus is illustrated in Figure 6. Generally, as shown in Figure 6, supplemental nitrogen will be required if manure is only applied to meet the phosphorus needs of the corn.

SUMMARY

A basic understanding of soil nutrient processes, mineralization rates of nutrients from manures and crop nutrient requirements as outlined here will hopefully facilitate the understanding and adoption of manure nutrient best management practices. Rarely do management recommendations work in practice exactly as anticipated. However, with a good understanding of the principles behind the practices adjustments can be made to increase the likelihood that the desired result of implementing a practice or management program will be achieved.

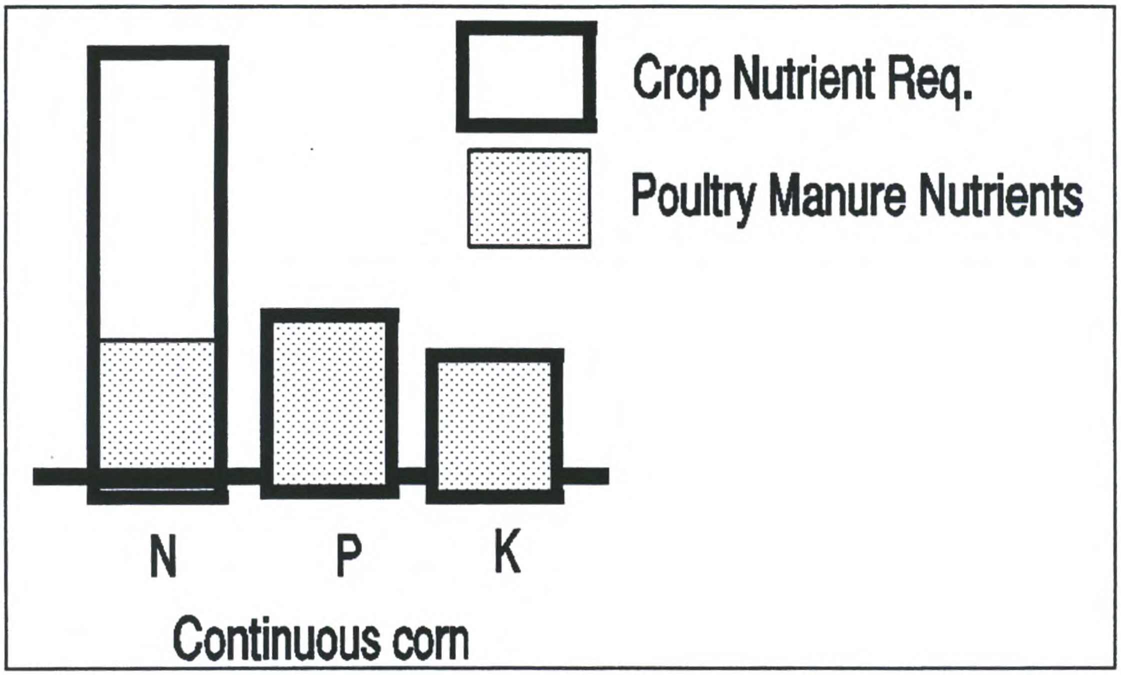

Figure 6. Crop nutrient requirement for corn grain vs. poultry manure nutrients, for manure applied to meet the phosphorus needs of a continuous corn crop.

MANURE AND SOIL ANALYSIS

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Poultry and other livestock wastes have been used as fertilizers for crop production since the advent of agriculture. Only in recent times, since the mid-1940s, have manure and other organic fertilizers been viewed as "wastes". Since then, farmers have relied on relatively cheap manufactured inorganic fertilizers because they are generally less bulky, have greater homogeneity, and are available in more nutrient-dense formulations.

A variety of treatment processes have been promoted for poultry wastes, many of which produce a by-product such as energy or composted soil conditioners. However, land application will be the point of end use for most litter and manure disposal plans. Therefore, it will be important for farmers to have a good understanding of effective use of livestock manures as fertilizer substitutes. The preliminary step in any such program will be effective sampling and analysis of litter, manure, and field soils so that nutrient management planning can be as effective as possible.

FACTORS THAT INFLUENCE MANURE PROPERTIES

Many factors influence manure properties. Some of these include bird species, age, diet, productivity, management, and environment.

Moisture management in production facilities is one of the environmental factors that can greatly affect litter nutrient content. As the litter becomes wetter, more ammonia is released and the nitrogen content of the litter decreases. Nitrogen is usually better conserved when litter is taken directly from production houses and spread, or when it is stored in roofed structures built for that purpose. In either condition, litter will be protected from exposure to rain and other weather factors that dilute nitrogen and other nutrients. Moisture may also cause wet, anaerobic pockets to develop in the stack hastening the conversion and release of ammonia gas. Typical nitrogen (N) values are shown in Table 1.

TABLE 1. Nitrogen in broiler and turkey litter (wet basis) kg/t (lbs/ton), and percent (dry basis)

Litter Storage Method	TNK[1], kg/t (lbs/ton)	TKN Percent	NK_4, kg/t (lbs/ton)	NH_4 Percent
Broiler litter, direct from house	30.85 (61.70)	4.31	7.22 (14.44)	1.03
Broiler litter, stacked/uncovered	28.40 (60.84)	4.30	6.94 (13.88)	1.07
Broiler litter, stacked/plastic covered	31.51 (63.00)	4.34	6.81 (13.61)	0.97
Broiler litter, stacked/roofed shed	33.33 (66.65)	4.57	7.96 (15.9)	1.11
Turkey litter, direct from house	32.15 (64.30)	4.77	10.39 (20.76)	1.56
Turkey litter, stacked uncovered	27.10 (54.18)	4.75	9.12 (18.57)	1.64
Turkey litter, stacked/plastic covered	22.25 (44.50)	4.33	9.83 (19.66)	1.98
Turkey litter, stacked/roofed shed	30.51 (61.00)	4.36	9.62 (19.24)	1.39

[1]TKN = Total Kjeldahl Nitrogen.
Source: Collins et al. (1995).

Heavier deposits of manure and moisture tend to form crusted or caked areas of litter around waterers and feeders. The result is a litter with different handling and nutrient characteristics than the other house litter. This manure cake represents 30-35% of the whole litter, is usually wetter, and has lower nutrient content than whole house litter.

Phosphorus (P) is largely immobile and does not move appreciably from the litter. There is evidence that litter, when stored outdoors or in systems that are not well protected from weather and other environmental effects, may be prone to deterioration that tends to shrink litter volume while concentrating P in the remaining litter. Material from such stacks will typically display higher levels of P than litter taken directly from houses. Typical litter P values are shown in Table 2, and typical potassium (K), calcium (Ca), and magnesium (Mg) levels are shown in Tables 3, 4, and 5, respectively.

TABLE 2. Mean phosphorus (P_2O_5) values (wet basis) for broiler and turkey litter, kg/t (lbs/ton), percent (dry basis).

Litter Storage Method	P_2O^5, kg/t (lbs/ton)	P_2O_5, Percent
Broiler litter, direct from house	20.99 (61.97)	4.34
Broiler litter stacked, uncovered	31.03 (62.06)	4.88
Broiler litter stacked, covered with plastic	29.28 (58.55)	4.07
Turkey litter, direct from house	32.26 (64.52)	4.78
Turkey litter stacked, uncovered	29.32 (58.63)	5.28
Turkey litter stacked, covered with plastic	31.62 (63.23)	6.26
Turkey litter stacked, roofed shed	31.56 (63.12)	4.52

Source: Collins et al. (1995)

Both bedding and water dilute manure, resulting in less nutrient value per pound. Substantial nitrogen can be lost to the atmosphere as ammonia. This typically occurs when conditions are created that stimulate the generation and release of NH_3, such as anaerobic conditions, or conditions that favor aerobic composting. The smallest nitrogen losses are associated with slurry storage pits, dry house whole litter and roofed storages. Deep pit manure stacking and open stockpiled litter have moderate to high nitrogen losses, while lagoons have the highest loss.

Phosphorus and potassium losses are usually negligible except for lagoons. Much of the phosphorus in lagoons is concentrated in, and is recoverable with the bottom sludge.

Moderate amounts of potassium may also be lost from open uncovered stockpiles by leaching.

TABLE 3. Mean potassium (K_2O) values (wet basis) for broiler and turkey litter, kg/t (lbs/ton), and percent (dry basis)

Litter Storage Method	K_2O, kg/t (lbs/ton)	K_2O, Percent
Broiler litter, direct from house	14.95 (29.900	2.09
Broiler litter stacked, uncovered	13.60 (27.19)	2.08
Broiler litter stacked, covered with plastic	14.48 (28.95)	2.02
Broiler litter stacked, roofed shed	15.78 (30.00)	2.05
Turkey litter, direct from house	11.88 (23.76)	1.77
Turkey litter stacked, uncovered	12.67 (25.34)	2.23
Turkey litter stacked, covered with plastic	10.87 (21.74)	2.11
Turkey litter stacked, roofed shed	13.37 (26.74)	1.91

Source Collins et al. (1995)

TABLE 4. Mean calcium (Ca) values (wet basis) for broiler and turkey litter, kg/t (lbs/ton), and percent (dry basis)

Litter Storage Method	Ca, kg/t (lbs/ton)	Ca, Percent
Litter, direct from house	19.47 (38.93)	2.73
Stacked litter, uncovered	19.99 (40.00)	3.15
Stacked litter, plastic covered	19.5 (39.10)	2.71
Stacked litter, roofed shed	20.56 (41.11)	2.80
Turkey litter, direct from house	22.17 (44.34)	3.28
Litter stacked, uncovered	19.36 (38.71)	3.51
Litter stacked, covered w/plastic	18.70 (37.40)	3.72
Litter stacked, roofed shed	20.45 (40.90)	2.92

Source: Collins et al. (1995)

TABLE 5. Mean magnesium (Mg) values (wet basis) for broiler and turkey litter, kg/t (lbs/ton), and percent (dry basis)

Litter Storage Method	Mg, kg/t (lbs/ton)	Mg, Percent
Broiler litter, direct from house	4.07 (8.14)	5.71
Broiler litter stacked, uncovered	4.15 (8.30)	6.50
Broiler litter stacked, covered with plastic	4.14 (8.28)	5.73
Broiler litter stacked, roofed shed	4.39 (8.78)	5.94
Turkey litter, direct from house	3.41 (6.79)	0.51
Turkey litter stacked, uncovered	3.27 (6.54)	0.59
Turkey litter stacked, plastic covered	3.76 (7.52)	0.75
Turkey litter stacked, roofed shed	3.54 (7.09)	0.51

Source: Collins et al. (1995)

SAMPLING AND CHARACTERIZATION OF MANURE

Several broad assumptions are necessary to use manure in place of, or in combination with fertilizers:

- Representative field samples can be obtained from poultry houses or storage areas;
- Samples can be accurately and quickly analyzed for N, P, and other nutrients;
- Sample nutrient values measured in the laboratory will closely approximate those applied in the field;
- Accurate estimates can be made of the availability of nitrogen from manure given the variable nature of soil and environmental conditions in the field, and field management conditions that also affect losses of nitrogen.

Representative Samples

The diverse nature of poultry litter and manure complicates the collection of a representative sample from storage systems such as litter sheds, house floors, manure tanks, or lagoons that contain hundreds of tons, or millions of gallons of material. Collecting a representative composite sample of litter or manure is the only way an accurate nutrient analysis can be assured. Analysis of a large number of samples increases the chance of an accurate analysis but is expensive, time consuming, and impractical. The next best thing is to understand the problem, and take care to prepare a composite sample that represents the bulk of litter or manure that will be spread.

In-house Broiler and Turkey Litter: Care must be taken to obtain a sample for analysis that represents the entire waste volume. Visually inspect the house floor for regions of varying litter quality such as areas around waterers and feeders (cake material). Estimate the percentage of floor areas represented by these areas. Collect six to twelve subsamples of litter, being careful to include the feeder/waterer areas in proportion to the total area of the floor they occupy. For example, if one-sixth of the floor area is cake, take one subsample from this area and five subsamples from the rest of the house. If the house will be only partially cleaned (or "caked"), then all subsamples should come from the feeder/waterer areas. Each subsample should include a 6" x 6" area down to the earth floor, taking care not to collect base soil below the litter. Mix the subsamples together in a nonmetallic container and place about a quart of the thoroughly mixed material in a clean plastic bag or bottle. Seal the container tightly, but allow space for gases that may be released to expand in the container.

Subsamples of scraped semi-solid layer manure should be collected either directly from collection gutters, or from the manure spreader, and placed in a nonmetallic sample container. partially fill the sample container (at least three-fourths full), leaving one-fourth of the container empty to allow for expansion.

Stockpiled Broiler or Turkey Litter: Subsamples should be taken from at least six representative areas of the litter stack using a penetrating sampling tube, or a small shovel. Subsamples should be taken from at least 18" into the pile. Avoid the dry surface layer of the pile. Thoroughly mix the material collected in a nonmetallic bucket or other container. Fill a clean plastic bag or other nonmetallic container with about a quart of litter from the container as described earlier.

Liquid Manure Slurry: Storage tanks or basins should be well agitated and homogenized with a liquid manure pump or propeller agitator before sampling. Grab samples should then be taken from at least six locations in the storage system and mixed in a nonmetallic container. The composite sample jar should then be partially filled from the mixture of collected waste in the larger container. Alternatively, grab samples may be taken from a gravity unloading pipe or pump discharge as the spreader is being loaded. At least six grab samples should be combined in a nonmetallic container, thoroughly mixed, and about three-fourths pints of the mixed material placed into a nonmetallic sample container. Be sure to leave about one-fourth of the sample container empty to allow for expansion of manure gases.

Lagoon Supernatant: Lagoons should not be confused with liquid manure storage basins. Lagoons are most often associated with treatment and holding of layer wastes, and the supernatant is typically very high (99+%) in moisture content.

If a lagoon recycle system is being used for in-house waste flushing, the laboratory sample may be taken directly from the header pipe discharge or flush tank. Fill a nonmetallic sample container partially (at least three-fourths full), leaving one-fourth of the container empty to allow for expansion.

The laboratory sample may also be taken by collecting grab samples from the lagoon. Tape a small bottle on the end of a 10-15 ft. pole, and extend the bottle 10-15 ft. from the bank edge. Take care to skim away any scum or debris that is floating on the lagoon surface so that it is not collected in the bottle. Submerge the bottle one foot beneath the liquid surface before rotating it to the upright position for filling. Repeat the process at least six times at different locations around the lagoon, each time placing the collected material into a nonmetallic container. Thoroughly mix the contents of the container, and add three-fourths pints to a nonmetallic sample jar. If a multistage lagoon system is involved, be sure to collect from the cell from which waste will be spread.

The results from a regular sampling program should be entered into a records database that is farm-specific. Once actual farm averages have been developed, they should be useful in making management decisions.

LABORATORY ANALYSIS OF LITTER AND MANURE

The storage and handling of litter and manure can alter the proportions of nitrogenous compounds, and other waste characteristics such as Biochemical Oxygen Demand (BOD). Sample handling, similarly, can influence laboratory results and cause errors in the estimates of nutrient levels (especially nitrogen) in the litter or manure that will be field applied. Some laboratories have developed recommended procedures for sample handling and transfer from farm to laboratory to reduce these effects. Once a representative sample has been collected, it should be delivered to an analytical lab quickly. Some states provide these analytical services for a fee at subsidized rates. Commercial laboratories also provide total nutrient and other parameter analyses.

Dougherty et al. (1995) examined effects of four preservation techniques on the form and concentration of nitrogen in poultry litter samples while in transit to the testing laboratory. They concluded that storage under ambient (26°C) conditions provided results as good, or better than refrigeration, freezing, or acidification with H_2SO_4 for making field application recommendations.

As a practical matter, changes will continue to take place within the sampled material until it arrives in the laboratory and is analyzed. These will not be serious given the other inaccuracies in handling, spreading, and otherwise processing manure or litter. However, opportunity for changes in the sample, and accompanying errors in estimating nutrient content of wastes spread, may be minimized by refrigerating, ice packing, or making sure that samples are dispatched to a testing laboratory quickly (i.e., not left in the pickup truck for a week or two before transfer!).

SAMPLING AND CHARACTERIZATION OF LITTER- OR MANURE-AMENDED SOILS

Testing the entire volume of soil in a field is not practical, so the next best approach is to collect sufficient samples to detect the chemical and fertility status of the field or area. Methods for testing soils and making agronomic recommendations for use of commercial fertilizers are well known and widely accepted. Soil testing continues to be a useful and economically beneficial practice for determining availability of P, K, and secondary and micronutrients. The availability of N in the soil is difficult to measure and predict because of the complex N reactions in the soil system. In contrast to the other major nutrients, N recommendations are based on yield goals, that are often based on soil productivity indices that vary with soil physical and chemical characteristics. A regular soil testing program is critical to determining pH, P, K, calcium, magnesium and other various micro nutrients. Soil testing is available from many state cooperative extension services, or from private laboratories.

Different nutrients may dictate different sampling techniques. The mobility and seasonal biological activity that affect certain nutrients imply that time of year and sample depth may be important. Sampling for nitrate and sulfate, which are mobile nutrients, needs to occur annually to rooting depths, 24 to 48 inches if possible. Sampling should be done when biological activity is low, and if possible, just before the crop begins to use the nutrients. Nutrients that are less mobile, such as P and K, require fewer depth samples and a less specific time of sampling. Usually, sampling at the time that is optimum for mobile nutrients will meet the requirements for all nutrients.

Thom and Sabbe (1994) present an overview of research and experience to improve the accuracy of soil sampling. Each field should be tested after each crop rotation. All crop fields should be tested at least once every three years. Sabbe and Marx (1987) proposed a zigzag scheme for sampling both rectangular and triangular shaped fields. Using a systematic core sampling plan using knowledge of the method of fertilizer placement is advisable, and following the zigzag pattern across the field to obtain at least 15 to 20 cores, despite field size. If the field has been tilled before sampling and the location of crop rows is obliterated, then more cores (20-30) should be collected at random in the zigzag pattern to lessen the effect on field results from inadvertently sampling earlier fertilizer bands. Samples should be taken with a tube or auger if possible. Composite samples should be collected to include at least five subsamples or cores from each acre represented by the composite sample. At least fifteen cores should be taken for each composite sample as mentioned above. Sampling depth should extend to the plow depth in cropland, and into the top two-to-four inches in pasture or sod. Cores should be thoroughly mixed in a nonmetallic container before the composite sample is assembled. Avoid soil conditions that are very wet or very dry; otherwise, good mixing will be difficult in the nonmetallic container.

As mentioned earlier, due to seasonal biological activity and mobility, soil N is not reliably predicted from soil testing since it will not accurately reflect the availability of N when it is most important to the crop. The lack of a relationship between a preplant soil test and the N needs of the crop is due to plant-available N gains from mineralization and losses of available N through leaching and dentrification. This factor is of particular concern with application of litter and manure, which contain a large proportion of N in the organic form.

Advances is soil and plant N testing have provided new tools that enable management of litter and manure-amended soils in a more environmentally sound manner. The most promising test, perhaps, is the pre-sidedress soil nitrate test (PSNT) developed by Magdoff et al. (1984). A key assumption of the procedure is that soils that frequently receive organic sources of N, such as from sludges, legume residues, and animal manures, will have a large pool of plant-available N. Often this pool will be large enough to meet most, if not all of the N requirement of the crop.

The PSNT is based on sampling of the surface one-foot of soil after the soil warms and the crop is growing. The amount of NO_3 in the soil sample represents the plant-available N that will mineralize from soil organic matter. This, side-dress N fertilizer recommendations can be modified, depending on the level of NO_3 found in the soil.

PSNT test procedures (for corn) are as follow (Evanylo and Alley, 1996):

- Conduct the test only on fields that have received no more N than a starter fertilizer application (25-30 lbs/acre). Fields that have received manure can and should be tested before making any supplemental N fertilizer applications at side-dress rates;
- Take soil samples when corn has reached a height of 10-15 inches at the whorl, not with an upper leaf extended;
- Sample soil by taking 10-20 cores across the field to a depth of 12 inches, if possible, or as deep as possible. Sample between rows to avoid starter fertilizer bands and areas where roots have depleted soil N;
- Combine, mix, crumble, and dry samples as quickly as possible by spreading the mixed soil in a thin layer on newspaper in a warm place. Samples can also be dried in an oven at low heat (200-225 ^{o}F), or in a microwave for 5-8 minutes at the high power setting;
- Use a reliable field test kit to determine soil NO_3 concentration. The Nitrate Quick Test kit marketed by Hawk Creek Laboratories, and developed with Pennsylvania State University, has performed well in many states. Similar kits are available from other suppliers. All field kits must be carefully calibrated and maintained in order to obtain reliable results.

When the soil NO_3 level has been determined, the following guidelines may be used:

NO_3 Concentration	N Rate Recommendation
< 11 ppm	Apply full rate of side-dress N that is needed for the realistic yield goal for the particular soil.
11-20 ppm	Possible reduction of the normal side-dress N application by 20-50%. The exact range is uncertain, and decisions must be made on a site-by-site basis and should take into account previous field history, organic N additions, and management practices.
> 20 ppm	No side-dress N is needed.

The above chart is provided to aid in understanding the use of the PSNT. Soil fertilization recommendations should not only incorporate results of the PSNT, but also include experience and understanding of the roles of soil properties and management practices in influencing N availability to crops.

SUMMARY

Accurate sampling of litter and manure, and field soils, is primary to development of effective nutrient management planning. Average nutrient values are available for various litter and manure handling and storage arrangements, but variability due to bird species, age, diet, productivity level, management, and environmental factors causes great variation from farm to farm.

The care taken in sampling of litter/manure and soils will ultimately determine how well manure applications match and provide nutrients at the level where they can be most effectively used by growing crops, and will help prevent the loss of nutrients into the environment. Because of seasonal biological activity and mobility, soil N is not reliably predicted from soil testing since it will not accurately reflect the availability of N when it is most important to the crop. The lack of relationship between a preplant soil test and the N needs of the crop is due to plant-available N gains from mineralization and losses of available N through leaching and dentrification.

New testing tools are now available that enable management of litter- and manure-amended soils in a more environmentally sound manner. One of these is the pre-sidedress soil nitrate test (PSNT). This test, and other similar ones, will help nutrient management planners better characterize the nitrogen status of field soils where animal wastes and other organic materials are used as soil amendments.

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MANURE APPLICATION PROBLEMS AND EQUIPMENT

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For manure/litter management to be effective, four things have to be considered. They are:

** Soil analysis
** Manure analysis
** Crop needs for realistic yield goals
** Manure application equipment

Soil and manure analysis and crop needs have been discussed. Therefore, manure application equipment will be the focus of this discussion. Box and spinner spreaders are the most common distribution equipment used to land apply poultry manure/litter. However, flail spreaders may be used but the discussion will be limited to box and spinner spreaders.

APPLICATION PROBLEMS AND EQUIPMENT

Box spreaders have rate and lateral distribution problems. This type of spreading equipment is designed primarily for cattle manures. In the past few years manufactures have made available optional gear reduction packages to limit the application rate. However, back tracking and lateral distribution are areas of opportunity. The box spreader is better at handling wet manure/litter than the spinner spreader because of lodging problems in the spinner spreader.

Spinner spreaders will distribute laterally, thus reducing soil compaction. Lower applications rates normally can be achieved with the spinner spreader (1-2 tons/acre). If straw is being used as in composting poultry mortalities, long stem straw will cause a problem by wrapping around the spinners.

Wet litter can cause lodging in the spreader body and cause a distribution rate problem. In many cases the discharge gate has to be open wider for the material to flow of the spreader.

Box and spinner spreaders can be used to distribute nutrients from poultry manure/litter. Determining the distribution rate and patterns are important so manure/litter is not over applied. A discussion of two calibration methods follows.

CALIBRATION

One grower in Maryland described his box spreader this way: "it throws the litter into the air and I drive out from under it without a clue as to the application rate". This points to a need for calibration. Calibration of your manure spreader will assist in applying only the necessary nutrients based on soil and manure analysis and crop needs for realistic yield goals. Figure 1 illustrates a procedure for calibration of a box or spinner spreader based on a known area. This procedure uses a plastic sheet (suggest 6 x 6 foot or 10 x 10 foot size sheet) or some other suitable material for the manure to fall on as it is discharged from the spreading equipment, a scale and a large bucket. There are several steps involved in this process. They are:

Step 1: Determine the sheet and bucket weight using an accurate scale.

Step 2: Place the plastic sheet securely in the field where the manure will be applied. The sheet should be placed at a location that will allow the manure spreader to be fully operational and the tractor or truck operating at the proper speed.

Step 3: Align the tractor and spreader on the center line of the plastic sheet. Operating at the proper speed (5-6 mph) drive across the plastic and back track on both sides. Back tracking is necessary because box spreaders have little or no lateral distribution. In the case of a spinner spreader, which has lateral distribution, three passes are also necessary: the first over the center line of the plastic sheet; the second and third 20 feet to the right and left of the center line for dry manure/litter; if the manure/litter is wet or caked material the distance should be 30 to 40 feet because the wet material will project further than the dry.

Step 4: Fold the plastic sheet so no manure/litter is spilled; place in the bucket and weigh using the same set of scales used previously.

Step 5: Subtract the initial weight of the plastic sheet and bucket (Step 1) from the weight determined in Step 4. The difference will be the manure/litter weight for a particular area.

Step 6: Repeat the process twice and determine the average weight of the manure/litter.

Step 7: If the 6 x 6 foot or 10 x 10 foot sheets were used, the application rate can be found in Table 1.

Step 8: If the plastic sheet size is different than those in Step 7, the following formula can be used to determine the application rate.

$$\text{Tons/acre} - \frac{\text{Pounds of manure x 21.8}}{\text{Area of the sheet (sq ft)}}$$

The known area method discussed above does not show the distribution of the nutrients. From the data collected by the pans shown in Figure 2, a "bell shaped" curve can be plotted (Figure 3) and a distance to the right and left of the center line determined for proper overlap. In the case of a box spreader back tracking would be appropriate. A similar plot can be determined for spinner spreaders. In Step 3 above, suggested distances were shown. These distances can be refined by the pan process. The process is similar to the area method but using 7 or 9 pans spaced equally apart. Determining the manure/litter captured in the pans and the distance from the center line for each pan a "bell shaped" curve can be plotted and distances for uniform distribution determined.

SUMMARY

A brief discussion of two commonly used manure spreaders used to spread poultry manure/litter have been discussed. The box spreader is better for manure and manures containing straw. For lateral distribution and application rate control the spinner spreader had merit. The area and pan methods for calibration were discussed. If you are just concerned about application rates use the area method. Use the pan method to assist in determining the uniformity of spread, particularly with the spinner spreader.

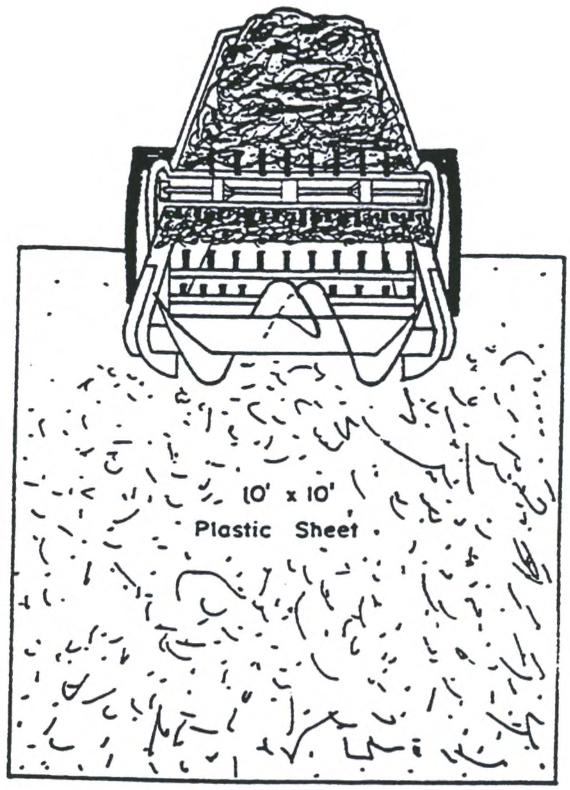

Figure 1. Box spreader calibration using the area method.

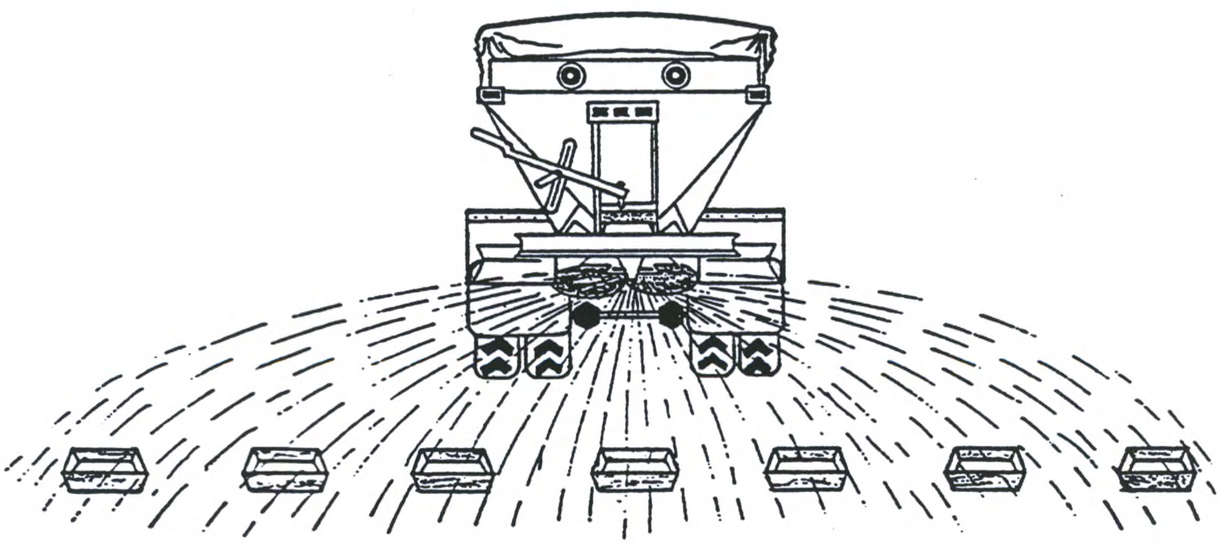

Figure 2. Spinner spreader calibration using the pan method.

TABLE 1. Manure spreader rate, in tons manure/acre

Pounds of Manure on Sheet	Sheet Size 6' x 6'	10' x 10'
5	3.0	1.1
6	3.6	1.3
7	4.2	1.5
8	4.8	1.7
9	5.4	2.0
10	6.1	2.2
11	6.7	2.4
12	7.3	2.6
13	7.9	2.8
14	8.5	3.1
15	9.1	3.3
16	9.7	3.5
17	10.3	3.7
18	10.9	3.9
19	11.5	4.1
20	12.1	4.4
21	12.7	4.6
22	13.3	4.8
23	13.9	5.0
24	14.5	5.2
25	15.1	5.7
26	15.7	5.7
27	16.3	5.9
28	16.9	6.1
29	17.5	6.3
30	18.2	6.5
31	18.8	6.8
32	19.4	7.0
33	20.0	7.2
34	20.6	7.4
35	21.2	7.6

Source: University of Maryland Nutrient Management Program Reference Manual.

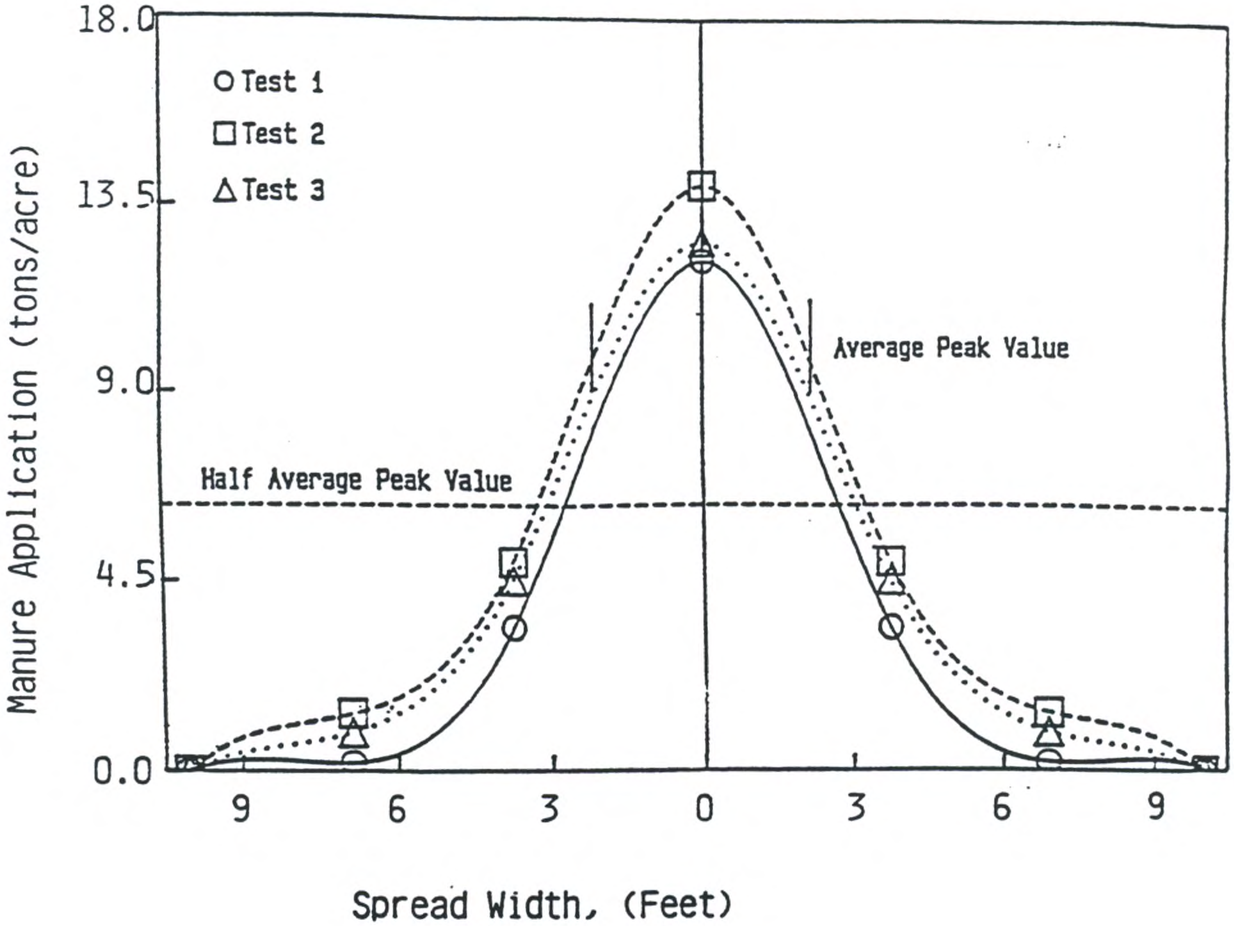

Figure 3. Calibration of a box spreader using the pan method.

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GROWING CORN WITH ORGANICALLY-ENHANCED FERTILIZER

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The Delmarva Peninsula is host to a large poultry industry. Sussex County in Delaware supports the highest poultry population density of any county in the United States. In 1995, growers in Sussex County will need to dispose of over 300,000 tons of poultry manure annually (Cabe Report to the University of Delaware); and this represents only part of the area's poultry production.

The University of Delaware has made a priority commitment to the region's billion dollar poultry industry to develop means of alleviating the potential disposal problem. In addition to joining the University of Delaware in its commitment to the poultry industry, the University of Maryland actively conducts programs to protect the Chesapeake Bay from potential agricultural pollutants. An innovative possible solution to the more widespread use of poultry manure has been investigated by Crop Production Services, Inc. through a product containing traditional chemical fertilizer which is organically enhanced with composted poultry manure. This product based on work by the Tennessee Valley Authority (Ransom and Strickland, 1992) has desirable properties of bulk density, particle hardness, consistency, improved odor control, and some slow release fertilizer content. In early 1993, a demonstration project was designed to evaluate this new product as an alternative starter fertilizer for corn.

A three year demonstration field trial was begun in 1993 to compare the agronomic effectiveness of a pelletized chemical fertilizer material, enhanced with composted poultry manure, versus traditional chemical fertilizer as starter fertilizer for corn production. The demonstration trial was conducted on a working farm which borders the Choptank River, a key tributary of the Chesapeake Bay, near Easton Maryland.

MATERIALS AND METHODS

In early spring of 1993, a field on the Boston Cliff farm near Easton, Maryland and owned by Dan Palmer was selected as the site for a field demonstration comparison of organically-enhanced starter fertilizer and commercial starter fertilizer. Soil samples from a 0 to 8 inch depth were obtained on March 10, 1993. The soil sample was analyzed by the University of Delaware Soil Testing Laboratory and indicated a pH of 6.4, phosphorus index value of 216 (above 100 is considered excessive), potash index value of 168 (excessive), magnesium and calcium indexes of 156 and 126, respectively, 74 lbs/A available manganese, and 11 lbs/A available zinc.

Soil fertility at the selected site was quite high. The excessive phosphorus level occurred, in part, due to past cropping practices when a large quantity of poultry manure was used to fertilize corn. A high phosphorus level is common for many agricultural soils on Delmarva and was the reason for testing the organically-enhanced fertilizer material from Crop Production Services as a starter fertilizer. As a starter, the product provided plant available phosphorus for early corn growth in cool, wet soils while contributing little if any to the soil phosphorus reserve level. There is potential concern for phosphorus as a possible pollutant from agricultural land when excessive levels buildup in the soil. As a starter, this material provided nearly the same amount of phosphorus as the crop used during the growing season.

On May 3, May 13, and April 26 in 1993, 1994, and 1995, respectively, plots were planted using DeKalb brand DK588 corn at a seeding rate of about 24,000 seed per acre. Furadan (4L) was applied in-furrow at 1 qt/A. The seedbed was conventionally prepared and weed-free. On May 4, 1993, 2 qt/A of Bicep and on May 13, 1994, 3 qt/A of Bullet was mixed with 20 gallons per acre of 30% UAN (urea-ammonium nitrate solution) (65 lb N/A) and applied for weed control and initial crop nitrogen needs. In 1995, Bicep II at 1.8 qt/A plus 1.5 pt/A Aatrex (atrazine) was applied at planting in 20 gallons per acre of 30% UAN. Additional nitrogen, 18 gal/A in 1993 and 1994 and 20 gal/A in 1995, was supplied at sidedress time.

The experimental design was a randomized complete block with six replications (Vasilas et al., 1992). Strip plots were approximately 900 by 30 feet in size. Treatments compared were either a commercially blended starter fertilizer with a guaranteed analysis of 10-20-2 in 1993 and 10-23-1 in 1994 and 1995 or an organically-enhanced fertilizer with a guaranteed analysis of 10-23-1 (all years).

Prior to planting, the planter fertilizer attachment was calibrated with both fertilizer materials to obtain nearly equal application rates for the two fertilizers. The average application rate was about 225 lbs/A in all years.

After planting, pre-sidedress soil nitrogen test (PSNT) samples from a 12-inch depth were obtained from each plot. Following harvest, another series of PSNT soil samples were obtained to quantify residual soil nitrate nitrogen levels.

Agronomic data collected included plant population (taken late May or early June and again at harvest); grain yield; grain moisture; test weight; percentage ear drop, soft stalks, ear lodging, root lodging, stalk lodging, and barren plants; soil nitrogen by PSNT test, at planting and following harvest; and soil fertility levels (early spring and following harvest).

RESULTS AND DISCUSSION

In 1993 and 1995, no significant differences were observed for any agronomic or soil characteristic measured. In 1994, all agronomic and soil characteristics were not statistically different except for root lodging. Root lodging was significantly greater (at the 10 percent probability level) where the commercial starter was applied (Table 1).

TABLE 1. Grain yield and other agronomically important characteristics of corn grown using a traditional complete starter fertilizer and an organically-enhanced starter fertilizer, Palmer Farm, 1993 to 1995, Easton, MD

Agronomic character	Commercial starter			Organically-enhanced starter		
	1993	1994	1995	1993	1994	1995
Grain yield (bu/A)*	124[a]	173[x]	134[m]	128[a]	176[y]	135[m]
PSNT ppm N (spring)	39.6[a]	18.4[x]	21.5[m]	36.6[a]	19.9[x]	16.4[m]
Grain moist. (%)	15.2[a]	15.2[x]	16.1[m]	15.2[a]	15.2[x]	16.1[m]
Test weight (lb/bu)	58.0[a]	57.0[x]	57.7[m]	58.2[a]	57.2[x]	57.7[m]
Final plant population (plt/A)	23,474[a]	22,337[x]	2546[m]	23,184[a]	22,535[x]	2488[m]
Soft stalked plts (%)	20.0[a]	4.04[x]	13.3[m]	14.2[a]	3.86[x]	11.8[m]
Ear drop (%)	0.2[a]	0.3[x]	0.0[m]	0.2[a]	0.0[x]	0.0[m]
Stalk lodging (%)	0.2[a]	2.0[x]	0.5[m]	0.0[a]	1.6[x]	0.3[m]
Root lodging (%)	---	13.1[x]	0.2[m]	---	8.7[y]	0.0[m]
Ear lodging (%)	2.7[a]	3.0[x]	0.8[m]	1.3[a]	2.7[x]	0.2[m]
Barren plants (%)	5.6[a]	2.1[x]	1.7[m]	9.0[a]	2.7[x]	0.8[m]
Fall residual N (ppm)	8.5[a]	6.9[x]	na	6.3[a]	5.2[x]	na

*Grain yield adjusted to 15.5 percent moisture and 56 lb/bu.
[a,x]Values with same letter within a row and within a year are not statistically different according to 'Fisher-protected' least significant difference test (P<0.01).

In 1993, grain yield averaged 128 bu/A (2.65 percent greater than that under the commercial starter) for the organically-enhanced starter fertilizer and 124 bu/A for the commercial starter fertilizer (Table 1). When adjusted for the number of barren plants and when adjusted to a constant plant population, yield for the organically-enhanced starter fertilizer was 7.3 percent greater than that for the commercial starter.

In 1994, excellent moisture conditions increased the trial average yield to 175 bu/A or nearly 50 bu/A greater than that in 1993 (Table 1). Grain yield was statistically significant between treatments at a 10 percent probability level due in part to a very low coefficient of variability (% CV) (unexplained yield variations not controlled for by the experimental design) of 1.1 percent. A good study usually has a CV of 10 to 15 percent. Yield of corn grown with the organically-enhanced starter fertilizer was 176 bu/A versus 173 bu/A for the commercial starter or a 1.7 percent increase in yield as compared with the 2.7 percent yield increase in 1993.

In 1995, yields were lower than in 1994 but similar to 1993 due to limited rainfall (Table 1). Organically-enhanced fertilizer produced 135 bu/A versus 133 bu/A for the commercial fertilizer treatment. There was not a significant yield difference between the treatments. All other agronomic measurements were not significantly different.

In 1993 and 1995, the PSNT test in the spring showed a slightly higher but not significantly different soil nitrate nitrogen level in the commercial starter treatment; but in 1994, this trend was reversed. The same 1993 trend was evident in the fall PSNT test when the commercial fertilizer treatment showed 8.5 ppm in 1993 and 6.9 ppm in 1994 residual soil nitrogen and the organically-enhanced starter treatment showed 6.3 ppm in 1993 and 5.2 ppm in 1994 residual soil nitrogen. This has environmental implications if it holds up in grower fields. Soil fertility information was obtained in each year but no significant differences or trends were evident.

SUMMARY

The hypothesis of the study was that organically-enhanced and commercial fertilizer materials of similar analysis are equally effective as starter fertilizer for field corn. The hypothesis was proven. Growers can safely use organically-enhanced fertilizer products to replace traditional chemical fertilizer starters without any reduction in yield potential. Organically-enhanced fertilizers can provide all the nitrogen and phosphorus needed to sustain early growth of corn.

From an environmental viewpoint, application of phosphorus at a rate equivalent to that removed by the crop improves the sustainability of the cropping system. In addition in the two years measured, there was a trend (although not statistically significant) for slightly lower residual soil nitrogen levels following harvest. This would reduce the nitrogen leaching potential during the winter months.

Growers who want to use a starter fertilizer product that is effective in feeding corn early in the season and is also both environmentally and socially responsible should give serious consideration to products similar to the organically-enhanced fertilizer tested in this study. The use of animal waste by-products in this manner will allow the waste to be spread over the largest possible acreage at fertilizer application rates that are more compatible with the environmental concerns of today.

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MANURE TRANSPORT SERVICES

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Our business is commercial trucking. We specialize in hauling poultry manure and litter but also haul bark mulch and other agricultural products of a seasonal nature to keep us busy year around. Twelve years ago we were farming about 800 acres in corn, beans and potatoes and ran some beef cattle. At that time we were spreading some manure from my father-in-law's hen houses, and needed a better way with less cost to haul and spread the manure on the fields. When we started talking to equipment salesmen about spreading equipment, and what we needed, they just didn't have what we wanted. That was when we built our first truck. Starting with a 20 ft. potato box we used the sloped bottom design with a web drag system in the trough to carry the manure to the rear of the truck where a spinner was mounted to evenly distribute the manure. The larger box was necessary to get heavier loads (17 ton) with some low density, dry manure.

EQUIPMENT

Today we run three similar spreader trucks, one tractor trailer, two skid loaders and two loading ramp trailers. All vehicles have commercial licenses, pay fuel taxes are insured and are PA utility commission certified. The tractor trailer is new this year, has a 24 ton capacity and a walking floor for unloading. The skid loaders have an 80 in. wide bucket with a capacity for about three yards of material. There are a lot of my customers that participate in the PA Egg Quality Assurance Program which means they wash and disinfect houses at the end of each flock. This generated the need to squeegee out the water remaining in the pit of a high rise layer house, which we do with a special rubber attachment to the skid loader. The loading ramp trailers were necessary on many farms without loading docks to get enough height to dump the skid loader bucket over the side wall of the truck box. We also haul the skid loader to the job site on the trailer.

MANURE HANDLING

The largest volume products we handle are high-rise hen house and pullet manure, as the company name suggests. Although we do load and spread some broiler, turkey and capon litter, and steer manure on a less regular basis.

Despite what you may think the concept of quality also applies to poultry manure. Moisture concentration of manure is an important consideration for us in terms of the time and cost involved in cleaning out a house. Moisture influences loading and spreading, as well as the quality and uniformity of the field application. You can be much more precise when spreading a dry uniform product vs. a wet product that clumps and sticks together. We divide the quality of manure we work with into three main categories: Premium at greater than 75% dry matter, Standard between 40-75% and Slop with less than 40% dry matter. We do some manure analysis on a regular basis but feel we have a good idea what the nutrient concentration will be. For example, when I talk with farmers I'll describe the Standard product as having about 40 lb. N, 65 lb. P, 35 lb. K, 90 lb. Ca and 8 lb. Mg. Although it depends on the field type and cropping plan we normally spread about 4-5 tons per acre. Our equipment is pretty accurate in the range of 2-8 tons per acre.

People often ask how long does it take to clean out a high-rise hen house. That really depends on the hauling distance as well as the manure quality or dry matter. We work primarily here in Southeastern Pennsylvania and the runs to the field are not too far. The furthest runs we make are to New Jersey with a Premium type product at about 120 miles one way. But if the haul is less than 10 miles for a 120,000 bird hen house that's stored manure for one year, we clean out in about two days time. Another thing we do on a regular basis is clean and disinfect our equipment between farms. That puts a truck driver in a clean truck in the morning and gets his day off to a good start.

Our employees are an important part of the business because we have a lot of repeat customers that demand a good job. Communication about the clean out date and if there are any weather delays are important to our customers. We make sure the load-out doors in the pit are closed tight at the end of the day and never go upstairs with the birds for biosecurity reasons. The egg producer has a huge investment in birds and equipment and we respect that.

SUMMARY

The poultry industry in Southeastern Pennsylvania has gotten highly specialized in recent years. We have companies that only vaccinate, beak trim, service birds or clean and disinfect poultry houses. We try to provide a special service to poultry producers and the greater agricultural community by distributing the nutrients in a sound environmental manner. Overall, our growers producing vegetables, corn, and row crops are satisfied with our Hen House Fertilizer based on the repeat orders and the positive feed back we have received.

UTILIZING TURKEY WASTE FOR CROP PRODUCTION: A CASE STUDY

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All animal by-products contain plant nutrients. The nutrients, if managed properly, can be used as an animal feed supplement or as a plant fertilizer. Today, nutrients from manure sources play an important role in plant nutrition simply because of the quantity of manure that is land applied. Except for small amounts of poultry manure used in animal feed, the major portion of animal waste is applied to agricultural land as a fertilizer. Proper application of poultry waste results in increased crop yields and lower fertilizer costs while protecting ground and surface waters.

Before the summer of 1996, poultry farmers in North Carolina with dry litter waste management systems were required to:

1. Maintain litter removal records for one year, including the dates litter was removed, the estimated amount of litter removed and the location of the sites where litter was applied.

2. Apply litter at agronomic nitrogen (N) rates.

3. Maintain a 100 feet buffer between perennial waters and stockpiled litter.

4. Maintain records of the name, address and phone number of any third-party applicator of litter.

Recent legislation in North Carolina has expanded upon the requirements listed above. Now, poultry farms with a dry litter waste management system involving 30,000 or more birds must develop and implement a waste utilization plan prior to January 1, 1998. The goal of a waste utilization plan is to insure the proper utilization of manure nutrients on agricultural land while protecting the environment. A waste utilization plan consists of four main components: source, amount, timing and application. Sources considered in the plan include soil bound nutrients, commercial fertilizers, crop residues and animal wastes.

Amount: North Carolina legislation currently requires that litter be applied based on the crop N needs, which varies with crop type and the potential soil productivity (realistic yield expectation). In North Carolina, N rates are based per unit of crop yield (Table 1).

TABLE 1. Nitrogen fertilization guidelines

Commodity	lb N/Realistic Yield Expectation
Corn (grain)	1.0 to 1.25 lb N/bu
Corn (silage)	10 to 12 lb N/ton
Wheat (grain)	1.7 to 2.4 lb N/bu
Rye (grain)	1.7 to 2.4 lb N/bu
Barley (grain)	1.4 to 1.6 lb N/bu
Bermudagrass (hay[1])	40 to 50 lb N/dry ton
Tall fescue (hay[1])	40 to 50 lb N/dry ton
Millet (hay[1])	45 to 55 lb N/dry ton
Pine trees	40 to 60 lb N/acre/year

[1]Reduce N rate by 50% when grazing.

Placement: Waste placement affects the availability of manure nutrients for crop uptake. Application to the soil surface typically results in greater potential for nutrient loss through volatilization and runoff during heavy rains. Soil incorporation of the waste reduces the risks for both pathways of nutrient loss, in addition it reduces the potential for unpleasant odors.

Timing: Wastes should be applied when crops can best utilize the nutrients. Often, crop needs do not match the time when poultry farmers schedule the clean out of the dry litter.

Because timing of clean out and application are not synchronized, litter is often stockpiled until crops are actively growing crops or planting dates are within thirty days.

The tools for proper implementation of waste utilization plans are waste, soil and plant tissue analysis. Poultry farmers in North Carolina are required to sample waste within 60 days of land application and soil sample for nutrient analysis annually. Good farm managers recognize the use of these tools can increase crop yields, reduce fertilizer costs and protect surface and ground waters.

<u>Waste Analysis:</u> The average nitrogen content of poultry waste is often used for developing waste utilization plans, however, actual application rates are based on a waste analysis. Basing applications on averages can result in improper application rates. Insufficient applications will result in nutrient deficiencies which can reduce crop yield and quality. Excessive applications can negatively affect both the plant and the environment. Waste materials in North Carolina can be analyzed by the North Carolina Department of Agriculture, Agronomic Division at a cost of only $4.00.

<u>Soil Analysis:</u> While experienced farmers can usually recognize a well nourished crop, it is not possible to look at a soil and predict if the soil is too acid or if there are proper amounts of the essential nutrients present. Soils in North Carolina vary in their needs for lime and nutrients, depending on soil characteristics, previous fertilization levels, and the nutrient requirements of the crop to be grown. The goal of soil testing is to find out enough about the soil to provide economically and environmentally sound nutrient and lime recommendations. Soil in North Carolina can be analyzed by the North Carolina Department of Agriculture, Agronomic Division at no cost to the farmer.

<u>Plant Analysis:</u> A plant tissue analysis is also available from the North Carolina Department of Agriculture, Agronomic Division. Plant tissue analysis is used to determine if crops are suffering from nutrient deficiencies or toxicities. This tool is likely the most under utilized of the three tools needed for proper implementation of waste utilization plans. At a cost of only $4.00, farmers may well increase profits due to savings in fertilizer costs or increased yields.

When waste, soil and plant tissue analysis tools are utilized together to implement a waste management plan, the farmer protects the environment while maintaining or increasing crop yields and farm profits.

THE CRIMINALIZATION OF ENVIRONMENTAL LAW: IMPLICATIONS FOR AGRICULTURE

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The federal environmental criminal enforcement program began in the mid to late 1970s when the Department of Justice (DOJ) undertook some well-publicized prosecutions for environmental violations. The DOJ also created an environmental crimes section devoted exclusively to criminal prosecutions under the federal environmental protection laws.[1]

It was not, however, until the mid-1980s that the federal criminal enforcement program became aggressive. Increased public concern over the environment encouraged Congress to enact new environmental crimes provisions. At the request of the Environmental Protection Agency (EPA) Congress added new environmental crimes to existing statutes and significantly increased environmental criminal provisions already on the books. In addition, the EPA was given new investigatory powers and additional resources directed towards the criminal prosecution effort.[2] Many of the changes enacted by Congress were part of the Pollution Prosecution Act of 1990.[3] The criminal enforcement of environmental laws is now viewed as a national priority.[4]

Agricultural activities put farmers, ranchers and agribusinesses at risk as to environmental violations. Raising livestock, plowing, clearing land, draining water off property, repairing levees, fencing property, clearing draining ditches, using pesticides and other chemicals, controlling of predators, harvesting, storing and processing crops[5] can all potentially expose a farmer, rancher or agribusiness to criminal prosecution for environmental crimes.

CRIMINAL PROSECUTIONS

To those espousing "green values" virtually any violation of an environmental statute is viewed as criminal, regardless of the violator's criminal intent and the fact that some environmental crimes occur inadvertently as a side effect of normal productive activities.[6] As then Attorney General Richard Thornburgh told the National District Attorneys Association in 1989, "a polluter is a criminal who has violated the rights and sanctity of a living thing—the largest living organism in the known universe—the earth's environment."[7]

It is the belief of some EPA officials that 75% of individuals will comply with the law only if violators are punished and the requirements are perceived as mandatory. Criminal enforcement measures extend to that 75%.[8]

Attorney General Janet Reno told attendees in a course on the criminal enforcement of environmental law sponsored by the American Law Institute and American Bar Association, "Those who violate the law will have a heavy price to pay."[9]

Between fiscal years 1983 and 1993, the DOJ obtained environmental criminal indictments against 911 corporations and individuals and obtained 686 guilty pleas and convictions. A total of $212,408,903 criminal fines were assessed and 388 years of imprisonment were imposed (with nearly 191 years of actual confinement).[10]

In recent years the EPA has "beefed up" its efforts to bring criminal cases against polluters. At least 200 criminal investigators will soon be working on EPA criminal cases. Also, the Federal Bureau of Investigations has allocated an increasing number of staff hours to investigating EPA criminal cases[11] and has 500 pending cases.[12] The DOJ recently shifted 33 attorneys to its Environmental Crimes Section in response to the new demands.

Many states have enacted state environmental statutes that closely parallel federal legislation. Forty states, for example, have enacted laws similar to CERCLA. These "mini-superfunds" vary considerably from state to state, but they hold in common severe criminal sanctions. The same can be said for other state environmental statutes.

Although for years states treated air and water pollution as regulatory offenses instead of common law crimes, there is plenty of precedent for invoking state criminal law as to polluters. Examples of common law theories for the prosecution of environmental crime include assault, battery, and homicide, as well as traditional statutory offenses such as conspiracy, attempt, and solicitation.[13] States have often invoked their traditional police powers to prosecute polluters for the infliction of toxic harms on individuals and the environment.[14]

ARGUMENTS IN FAVOR OF ENVIRONMENTAL CRIMINAL PROSECUTIONS

Supporters of criminal prosecutions contend that environmental laws are public welfare statutes.[15] Because these laws RED protect the general health, safety, and welfare of the public, criminal prosecutions are absolutely necessary in that:

- Environmental laws seek to prevent harms that can be just as significant as those associated with more traditional criminal acts.[16]
- The moral culpability of violators of environmental laws is just as great as those who commit traditional crimes such as murder, robbery, or assault. Environmental violations have the potential of harming large numbers of people.[17]
- Unless criminal sanctions are severely applied to both individuals and corporations, environmental sanctions will simply be viewed as another cost of doing business.[18]

The EPA has been particularly defensive about its selection of cases for criminal prosecution. The EPA contends that it carefully evaluates and screens cases so that criminal charges are filed only against those most deserving of criminal prosecution. In evaluating whom to prosecute the agency looks at a number of factors including, but not limited to, a history of noncompliance or repeated violations; knowing and willful behavior; the concealment or falsification of violations; potential deterrent effect; and the impact of the violation's harm on human health or the depletion of natural resources.[19]

ARGUMENTS AGAINST THE USE OF CRIMINAL LAWS

Critics of federal criminal prosecutions agree that only the most serious environmental cases should be handled as criminal prosecutions and they point to legislative history in support of their position. They question, however, whether the EPA and DOJ are following Congressional intent.

A. Unfair Selection of Cases

According to Judson W. Starr, the director of the Environmental Crimes Section from 1982 to 1987, EPA's screening system for criminal prosecutions is not nearly as effective as the EPA contends. Starr says that the way a case is handled often depends on whose desk the case first arrives. If the case is first reviewed by an EPA regulatory employee, the case usually proceeds through administrative channels. If, however, the case is initially handled by an EPA criminal investigator, it tends to remain a criminal matter.[20]

In support of their criticism of the government's selection process, critics can point to a number of highly controversial and questionable criminal prosecutions. Ironically, many of these controversial prosecutions involve farmers, ranchers, and agribusinesses. The following is a brief summary of some of the cases:

- Taung Ming-Lin, an immigrant from Tiawan, arrived in the United States in 1991 and purchased 720 acres of desert land near Bakersfield, California. He planned to grow herbs and vegetables on what was described as barren soil. Unfortunately for Lin, his property was listed as natural habitat for the Tipton kangaroo rat, an endangered species. On Sunday, February 20, more than two dozen state and federal agents, accompanied by helicopters, descended upon Lin's farm to look for dead kangaroo rats. The agents supposedly found the remains of 5 rats and charged Lin with violating the Endangered Species Act. Eventually, authorities also accused him of farming San Joaquin kit foxes and blunt-nosed leopard lizards. Authorities seized numerous farm tools belonging to Lin and even filed a law suit against his Ford tractor which allegedly had killed the kangaroo rats. The authorities threatened Lin with a 3-year prison term and a $300,000 fine. They also demanded that he give up title to 363 acres of his 723-acre holding for which he had paid $1.5-million and that he pay another $172,425 to fund the operation of a wildlife preserve on the land he was deeding to the government. It was only after Lin suffered a mild stroke and the public expressed its outrage at the government's treatment of Lin that the charges against him were dropped. The government eventually agreed to only charge his corporation and finally settled with the corporation for a payment of $5,000 to a local habitat conservation fund.[21]

- William Ellen, a lifelong conservationist, received a 6-month prison term for creating 10 duck ponds on Tudor

Farms owned by Paul Tudor Jones II on Maryland's eastern shore in Dorchester County. He was convicted of violating the Clean Water Act by knowingly adding water to wetland areas. Ellen, a life-long conservationist, opposes indiscriminate hunting, donates to the environmental group, Greenpeace, and supports a Wildlife Fund sticker on the bumper of his Chevrolet Blazer.

While working on the 10 freshwater duck ponds for Tudor Farms, Ellen consulted frequently with local state and federal agencies, obtaining 38 permits in the process. The oversight agencies he consulted included the Soil Conservation Service, the Army Corps of Engineers, Maryland's Department of Natural Resources, and Dorchester County's Zoning and Planning Boards, all of which approved Tudor Farms' construction at some point. To supervise day to day operations and to ensure that no wetlands were filled, Ellen hired two former natural resources employees with experience in drawing state maps that delineated wetlands from uplands.[22] Despite Ellen's precautions, the Corps of Engineers accused him of damaging wetlands. The accusations against Ellen were made after the 1987 rules which expanded the technical meaning of wetlands and increased the wetland acreage of Dorchester County from 84,000 acres to 259,000 acres. Ellen was offered immunity from prosection if he would testify against Jones. Ellen refused because he did not believe that anything wrong had been done. Federal prosecutors then went ahead and prosecuted Ellen, obtained a conviction, and asked the court to sentence Ellen to 33 months in prison, the maximum allowed under federal guidelines. Ellen received a 6 month prison term and Jones eventually paid $2,000,000 in fines and restitution.[23]

- Ocie Mills and his son Cary spent most of 1989 and 1990 in jail for filling with clean sand a dry ditch on their quarter acre Florida lot. In addition, Mills and his son were each fined $10,000. The dry ditch was determined to be a wetland and the sand to be a pollutant. According to documents obtained under the Freedom of Information Act, officials of the Army Corps of Engineers were angry at Mills and his son whose criticisms of the Corps for the Corps efforts to regulate dry lands had been highly publicized.[24] After the Mills were released from jail, the government attempted to also charge them for not removing the sand. Fortunately, a federal judge rebuffed the government's efforts.

B. Justice or Extortion

In a number of criminal cases, the government has proposed settlements in which substantial donations to environmental causes have been exacted from defendants or in which attempts to exact such settlements have been made. The following two examples raise serious questions about the propriety of the government's conduct. In the case involving Bill Ellen and multi-millionaire Paul Tudor Jones, as part of the deal in which Jones received 18 months of probation, he agreed to make a $1-million contribution to the National Fish and Wildlife Foundation.

In the case filed against Taung Ming-Lin for allegedly killing kangaroo rats, the government threatened Ming-Lin with a $300,000 fine and a three-year prison term. As part of a proposed settlement of the criminal charges, the government demanded that he give up title to 363 acres of his 720-acre holding for which he had paid $1.5-million. The government also demanded that he pay another $172,425 to fund the operation of a wildlife preserve on the acreage he was to deed to the government. Intense cries of public outrage finally forced the government to settle for a $5,000 donation to a local habitat conservation fund.[25]

Many individuals accused of environmental crimes have no choice but to accept whatever settlement proposal is made by the government. They simply lack the financial resources to do otherwise. Oklahoma criminal defense attorney, Jarry McCombs, estimates that a competent environmental defense costs between $250,000 and $500,000. In an RCRA case against an aircraft painting and repair shop, McCombs said the defendant spent $300,000 to have his conviction overturned on appeal. The federal government spent $468,000 on its prosecution.

C. Diminished Mens Rea

Much of the criticism of the criminal enforcement of environmental laws revolves around the issue of mens rea. The common law generally did not condemn acts as criminal unless the actor had "an evil purpose or mental culpability." In addition, under common law an accused can only be convicted upon proof beyond a reasonable doubt that the accused acted with the "specific intent" to violate the law, in other words, that the accused acted with a conscious objective to cause the specific result proscribed by the statute.

In comparison, environmental offenses require only a diminished mens rea. The United States Supreme Court and the courts of appeal have generally held that the government can prove that a defendant "knowingly violated" a particular environmental standard without proving either that defendant knew of the applicable legal standard and its violation or of all the relevant facts underlying its violation.[26] The diminished mens rea requirement in environmental criminal cases is justified under the doctrine that environmental crimes are public welfare offenses.[27]

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13. Humphreys, S., 1990. "An Enemy of the People: Prosecuting the Corporate Polluter as a Common Law Criminal," 39 AM. U.L. REV. 311, 325.

14. Id. at 331, n. 114 citing People v. Union Oil Co., 74 Cal. Rptr. 78, 82 (1969) (prosecution permitted under Fish and Game Act for petroleum deposited into state waters); Commonwealth v. Sonneborn, 66 A.2d 584, 587 (1949) (prosecution permitted under statute prohibiting discharge of industrial waste into public waters); n. 116, citing State v. Buckman, 8 N.H. 203, 206 (1836) (holding the pollution of well by throwing dead animal carcass into it was indictable at common law); n. 117, citing Attorney Gen. v. Woburn, 79 N.E. 2d 187 (1948) (upholding statute prohibiting discharge into public waters of matter likely to create a public nuisance); see also Commonwealth v. Straight Creek Coal & Coke Co., 145 S.W. 738 (1912) (upholding indictment under water pollution statute).

15. Public Welfare statutes have been described by the United States Supreme Court as a congressional response to the Industrial Revolution:

"Wide distribution of goods become an instrument of wide distribution of harm when those who disperse food, drink, drugs, and even securities, did not comply with resonsable standards of quality, integrity, disclosure, and care. Such dangers have engendered increasingly numerous and detailed regulations which heighten the duties of those in control of particular industries, trades, properties or activities that affect public health, safety, and welfare. Morissette v. United States, 342 U.S. 246, 254 (1952).

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PERMIT NEGOTIATIONS

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Many permit applications offer a startling array of negotiating pathways. Stinginess at negotiating time may lead to sticker shock when it comes time to comply. This paper will identify some of the traps, how to avoid them in some cases, and use them to your advantage in others.

The principal topic of interest in this paper is on having the correct operatives on your side of the table. Environmental permit negotiation is analogous to playing five card stud. The owner must know at all times the value of the cards he holds. It is important to know what he stands to gain or lose by the play of each card, not only for now but in the future. Each card played has hidden capital and operating cost implications for wastewater treatment. Each card played can increase or decrease the owner's future exposure to penalties for permit violations. You have to be able to read the other side and, sometimes, educate them. It is very difficult for a permit writer to understand a position because many of them have no actual wastewater treatment experience. You'll never see me trying to tell a ballerina how to dance better because I have had no training or experience in that demanding art. I can only base my opinion on my observations from the theater and television. The permit writer has no choice but to venture his opinion, usually without the benefit of any real experience. That is what he is paid for.

It helps to have an engineer and attorney to identify the costs and the risk potential associated with each decision. Up front costs for this type of advice are minor when compared to the investment in treatment equipment, operating costs and enhanced risk. For instance, I was once brought in as an expert witness in a case where the penalty tab totaled

$83,000,000. They would only have had to pay a minuscule percentage of that to have been afforded greater protection before the violations occurred.

The final purpose of this paper is to serve as an entree for the description of a successful case I worked on. Therein is described the **P**roblems, **P**reparation, **P**lans, **P**ursuit, **P**ersistence and **P**ayoff from an actual case.

HOW TO AVOID A $6,500,000 CASH OUTLAY FOR PRETREATMENT

Problem

Ajax Manufacturing had agreed to pretreatment permit terms and a schedule of compliance to meet them based on their understanding of the capital and operating costs associated with a specific treatment technology. Jones Consulting told them to anticipate an investment of $1,250,000 with annual operating costs expected to be roughly $500,000. However, when preliminary design was begun, Jones Consulting learned that the unique character of the waste precluded the use of that equipment.

Enter Miracle Engineers, who said they had the answer. Ajax had learned from their first lesson and required Miracle to enter into an arrangement to design, build and **guarantee** the results. Enter your writer, at the recommendation of the attorney who was brought in to tackle the problem when Miracle's estimate reached $4,250,000. The annual operating costs now approached $700,000.

The British parent facility began to look elsewhere, where goods of the same quality could be produced at a lower cost. Two hundred U.S. jobs hung in the balance. And things got worse. Miracle had to continue with the design, ravenously chewing at their fee at the rate of $75,000 a week. Otherwise, the compliance deadline would be in jeopardy. And as they refined the design, the cost estimates continued to escalate. Four and a half million, five million and so on as we began preparations to address the problem.

Adding to the problem, our client had sold the part of the plant that was producing the pollutant in question. They were contractually committed to pay for pollution control for X years after the date of sale for the facilities just spun off.

Preparation

Preparation focussed on three issues. What were the bases for the permit limits? Was there a cheaper technology? Were other permit limits negotiable? As for the basis for the numeric limit for the heavy metal in question, if anybody knew, they weren't talking. We quickly concluded that there wasn't any cheaper technology that would work. Jones had struck out when they hadn't realized that much of the heavy metal was in chelated form. That was why it was not amenable to the cheaper coagulation/precipitation treatment. Further negotiations on the permit number hinged on our either figuring out where the number came from, or dismissing it as invalid under current circumstances.

Why the shroud of secrecy around number derivation? We never really found out because the issue was so sensitive and involved so many people with their separate agendas that we couldn't probe too deeply without threatening future permit negotiations. The discharge was to a sewer owned by one party and treatment was provided by a different public entity. The borough and township were advised on technical matters by a board made up of professors from the local university. The board could have conceivably ended up as the decision maker in what we were setting out to do.

Just to make things interesting, the cash strapped township announced they were putting the wastewater treatment plant up for sale, ostensibly to the highest bidder. The bidding and subsequent haggling over the sale would overlap any negotiations we would be undertaking. Clearly, the deal had to be cut before the plant was sold or, we would have to start all again with a new player.

We started our analysis with the pretreatment programs of which there were two, the borough's and the township's. Unfortunately, the numeric values for the metal, let's take literary license and call it copper, were different. The township value was actually higher than the borough's. A clinical inspection of the pretreatment program development documents revealed that the township number was to allow them to land apply their biosolids. Copper was the limiting factor. Conditions at the time of derivation were examined. Two major changes had occurred since then. The biosolids based copper value in the pretreatment ordinance was based on a state policy of the time, approximately ten years ago. This policy had been replaced by new EPA regulations, the 503 Biosolids criteria. A major increase in allowable copper application doses to the land had been made. Secondly, the methods of preparing the sludge for land application had also changed significantly, to the benefit of our client. All other possible regulatory constraints were checked to make sure we had a winner. The allowable interference value was higher as was the categorical pretreatment standard for Ajax. The regional authority's and the State's Water Quality Standards were compared with the the pass through value derived from estimating the township treatment plant's removal capacity for copper. The calculated values were again higher.

Based on the results of the detective work, we had a winner. Now we had to formulate a game winning plan for using the data.

Plan

Development was no cinch despite the fact that we knew that the pretreatment limit for copper should, and could, be much higher than it was going to be when the compliance date arrived. How much higher? We discovered that the discharge could be done with no pretreatment at all, even existing equipment could be done away with. Nonetheless, the dynamics of the situation made it clear that although a no pretreatment goal was technically feasible, it was politically impractical. We could create a convincing technical argument for the advisory board, but that wouldn't have done us any good if we couldn't get that far. We had to convince the mix of lay people, engineers and lawyers at the borough and township level first.

Our ultimate recipe included a robust stock of cash for the lay people, a helping of technical justification for the scientific types and an iron bound contract to thicken the roux. The plan offered:

> Cash to the township to continue treating the sludge as they were,
>
> Technical information to the borough, township and advisory board engineers and lawyers to demonstrate that our proposal offered compliance with all current regulations, and
>
> A contract that offered flexibility to the township to change their method of sludge handling anytime if they found a cheaper way to dispose of it.

Pursuit

Pursuit of the prize began in earnest once our plan was in place. Although the township owned the treatment plant, the borough was the permitting authority which would ultimately be responsible for changing the problematic permit condition. We started by visiting the borough engineer, sans an attorney, to pitch our proposal and enlist his help in approaching the township. He agreed to set up a meeting with some reluctance, pointing out that the permit limit in question had taken ten years to develop.

If we thought our meeting with the borough engineer was somewhat disappointing, our naivete certainly didn't prepare us for the confrontation with the township engineer. This was also a `just we girls (no lawyers)' meeting on purpose. We wanted to keep it low key. So much for meticulous preparation and planning. In the middle of our presentation, he lunged from his chair, announced how sickened he was with our proposal and proceeded to leave the room. Fortunately the plant manager, our client, recognized this as an old labor union negotiating tactic. As he explained it, any time you had to use the rest room during tense negotiations, you used it to your advantage. "Jump out of your chair screaming how outrageous your opponent's position is," he explained. "Then leave the room, relieve yourself and come back to the bargaining table feeling in a lot better mood to continue negotiations." And that is what the township engineer did. He rejected our technical argument out of hand.

Persistence

Negotiation persistence of this type is a mandatory axiom if you are to succeed in reaching your goal. Clearly, it was important to step up the action. At the next meeting, we purposely excluded the borough people but expanded the universe of participants to include the township's lawyer and politically appointed public works director. At this, and ensuing meetings, technical matters took a deep second position to the major subject of discussion. Hours were spent addressing how much cash the client was willing to pay to the township to continue treating the sludge in the manner which benefitted our client. The township held that this method of sludge treatment and disposal was far more costly than methods from which they were unduly precluded due to the presence of copper in copious amounts. Sludge handling costs of other major eastern seaboard cities were cited. In view of these potential savings, our original offer was viewed by the township as being ludicrously low. Our first meeting adjourned on that point.

We doggedly investigated the basis for the cited sludge handling costs by interviewing the public works facility staffs in Baltimore, Philadelphia and other cities mentioned in the first meeting. The quoted amounts turned out to be only for part of the total costs of sludge handling. With this information in hand, we returned to the bargaining table. Our disclosures were made subtly so as not to embarrass the township engineer who had cited the sludge costs at the original meeting. He continued to press for the need to have the flexibility to look at and implement other sludge handling methods but his comments had been effectively turned aside.

It was then we made our first cash offer, $100,000 per year if the township would continue to treat its sludge the beneficial way. The Public Works Director countered at the next meeting with a $500,000 annual payment for five years. The borough's weakness clearly was their dire need of money. This plus the fact that we were technically in the right were the lubricants for our deal.

Payoff

Payoff time can be sweet and ours was. We finally settled on a $300,000 annual payment for five years, renewable by the township for another five years at $400,000. This agreement in principle was subject to getting the pretreatment permit modification for copper approved by the borough and EPA. The modification we sought was for the permit copper limits to remain where they were. This would mean that Ajax would continue to operate their existing pretreatment facilities but would not have to upgrade them. The cost of the upgrade, by the way, had now escalated to $6,250,000 with an estimated annual operating cost of $800,000.

The negotiating emphasis now switched from money to the technical issues. We compiled the results of our regulatory analysis to demonstrate that all federal, state and local regulations would be satisfied if the modification was granted. We supplemented this with a rigorous scientific report. It described both the fate of copper in a wastewater treatment facility and the mechanism by which it interferes with the operation. As a result, the modification was made without a hitch before bids were taken on the sale of the township's wastewater treatment plant. The client saved more than $8,000,000.

CORRELATION OF WASTEWATER TEST RESULTS

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Biochemical oxygen demand (BOD_5) is a standard analytical procedure to determine the concentration of organics in the waste stream of a food processing plant. This procedure is used to determine the waste load from processing plants to be used for design of either pre-treatment plants or for biological treatment plants. Municipalities use BOD_5 as a parameter for wastewater strength discharged into municipal sewers and use BOD_5 as a parameter for regulatory compliance.

BOD_5 is, by definition, a five day analytical procedure. A processing plant can be out of compliance for more than a week, before the results of the previous week samples are known.

Analysis of poultry processing wastewater for BOD_5 and other methods of organics analysis, chemical oxygen demand (COD), total volatile solids (TVS), and total suspended solids (TSS), have shown a general relationship exists between these methods and BOD_5. Since the other procedures produce results much more rapidly than BOD_5, it would be valuable to predict BOD_5 based on its relationship to COD, TVS, or TSS.

MATERIALS AND METHODS

To establish these parameters, samples of three types of wastewater (from the primary offal screen, the feather screen, and final plant effluent) prior to physical/chemical pretreatment were obtained from three different poultry processing plants. Grab samples were taken from the three wastewater sources at nine (9) A.M. from each of three processing plants on three separate days.

Samples were transported within a short period of time to the Agricultural Services Laboratory at the University of Georgia for analysis for BOD_5, COD, TVS, and TSS. Prior to analyses for these four parameters, the grab samples were homogenized for 1.5 minutes using a Fisher Powergen homogenizer with a two (2) cm diameter generator. This was done to ensure homogenicity of the samples as particulate organics of substantial size were observed in the original grab samples. All samples were analyzed for the four parameters using accepted procedures as described in "Standard Methods for the Examination of Water and Wastewater."

RESULTS AND DISCUSSION

From data presented in Tables 1, 2 and 3 it is evident that large variations in wastewater strength occur from each of the three sources at any particular time during processing, this demonstrates that composite sampling over time is preferable to the grab type sampling employed in the present study. Composite sampling is sure to give a more accurate representation of waste stream strength.

From the data presented in Table 1, it would appear that the organic strength of wastewater from the primary offal screen is much less concentrated in plant #1 than is the waste water collected from the primary offal screens of plants #2 and #3. Although not addressed in this study, there are a number of possibilities for this outcome. Plant #1 may be putting less organics in the offal stream from the evisceration operation, they may be adding organics comparable to the other two plants but adding it to a greater volume of water, or the primary offal screen in plant #1 may be more efficient at removing organics from the waste stream. Analysis of feather screen water presented in Table 2 reveals that the concentration of organics from this source is similar at plants 1, 2, and 3.

Table 3 gives the results of the analyses of final plant effluent from plants 1, 2, and 3. While the organic strength of the effluent from all plants is comparable, there appears to be a substantial amount of variation within each of the three plants. Again, this may be the result of grab sampling rather than composite sampling.

TABLE 1. Characteristics of wastewater discharge from the primary offal screen at three broiler processing plants

Meat		BOD_5*	COD	TVS	TSS
Pl 1	1	2563	4663	2349	1840
	2	698	1120	612	604
	3	1842	2965	1544	1415
		1701	2916	1502	1286
Pl 2	1	3714	6540	3255	2940
	2	5013	7738	4000	3697
	3	4987	7195	3296	2435
		4571	7158	3517	3024
Pl 3	1	4115	6785	3747	4098
	2	3815	6600	3194	3050
	3	5165	9530	3772	3682
		4365	7638	3571	3610

*mg/L

TABLE 2. Characteristics of wastewater discharge from the feather screen at three broiler processing plants

Feather		BOD_5*	COD	TVS	TSS
Pl 1	1	2168	4550	2257	1753
	2	2467	3578	2001	1299
	3	4630	8290	3928	3160
		3088	5473	2729	2071
Pl 2	1	1892	3065	1561	1367
	2	2142	3585	1803	1424
	3	3787	5845	3041	2400
		2607	4165	2135	1730
Pl 3	1	2303	3833	1953	1541
	2	2185	5065	2468	1773
	3	2200	4513	2052	1568
		2229	4470	2158	1627

*mg/L

TABLE 3. Characteristics of wastewater discharge from the final plant effluent flow at three broiler processing plants

FPE		BOD_5*	COD	TVS	TSS
Pl 1	1	2930	4835	2340	2327
	2	1880	2460	1321	997
	3	3300	5435	2538	2170
		2703	4243	2066	1831
Pl 2	1	2580	4295	2434	2160
	2	3020	4823	2396	1983
	3	4403	6668	3201	2000
		3334	5262	3201	2048
Pl 3	1	3220	3315	2898	2490
	2	2995	3860	2645	2210
	3	4420	6018	2218	2032
		3545	4464	2587	2244

*mg/L

Data on the ratios of COD, TVS, and TSS to BOD_5 in water taken at offal screens is presented in Table 4. All of these ratios appear to show a fairly wide variability which serves to demonstrate that small samples, composited over time are likely to produce more consistent results and that variability seems to exist on a minute to minute basis within a given waste stream. This variation carries through with the data on feather screen water and final plant effluent presented in Tables 5 and 6. In addition to the variability between samples presented here, there is an inherent variability in all laboratory procedures, especially those such as BOD_5, which depends on microbial activity for the analysis.

Table 7 shows the average ratios between various analytical procedures on each wastewater source from all of the plants examined. From the data presented in this table, it is evident that with a greater number of samples, BOD_5 may be more accurately predicted using parameters with a much shorter analytical time than BOD_5. In the data presented here, the parameters of COD, TVS, and TSS were selected. It has been generally reported that the BOD_5 to COD ratio is between 0.5 and 0.6. The present study generally supports this, although for FPE (final plant effluent), a ratio of 0.65 was obtained. Perhaps as close as we can approximate the BOD_5 from COD data is that BOD_5 is probably between fifty and sixty-five percent of COD. While this is not as close an approximation as would be desired, it may be as close as we can get. Some of the underlying reasons for this may be the amount of fat in the wastestream at any given time. Although not addressed in the present study, previous work at plant 2 demonstrated that as the amount of fat increased in a wastestream, the BOD_5 to COD ratio decreased, possibly because the microbes in the BOD_5 analysis digest fat with somewhat more difficulty.

TABLE 4. Ratios of COD, TVS, and TSS to BOD_5 in water from the primary offal screens in three broiler processing plants

		$COD:BOD_5$	$TVS:BOD_5$	$TSS:BOD_5$
Plant 1	1	1.82	.92	.72
	2	1.60	.88	.87
	3	1.61	.84	.79
		1.68	.88	.79
Plant 2	1	1.76	.88	.79
	2	1.54	.80	.74
	3	1.44	.66	.49
		1.58	.78	.66
Plant 3	1	1.65	.91	1.00
	2	1.73	.84	.80
	3	1.85	.73	.71
		1.74	.83	.76
Range		1.44-1.85	.66-.92	.49-1.00

Table 8 shows the results of a single sampling of water from the evisceration wastestream at plant 2. Untreated evisceration wastewater had a TVS and FOG of 1656 mg/L and 1628 mg/L respectively. This water had a BOD_5 to COD ratio of 0.39. After gravity separation, the TVS and FOG were reduced to 697 mg/L and 364 mg/L respectively. Therefore, the FOG to TVS ratio was reduced from almost 1.00 to about 0.50. The BOD_5:COD ratio increased from 0.38 to 0.48. When this wastewater sample was chemically flocculated, TVS and FOG were reduced to 291 mg/L and 35 mg/L respectively for an FOG to TVS ratio of 0.12. The BOD_5 to COD ratio in this water was found to be 0.55.

TABLE 5. Ratios of COD, TVS, and TSS to BOD_5 in water from the feather screen operation in three broiler processing plants

		$COD:BOD_5$	$TVS:BOD_5$	$TSS:BOD_5$
Plant 1	1	2.10	1.04	.81
	2	1.45	.81	.53
	3	1.79	.85	.68
		1.78	.90	.67
Plant 2	1	1.62	.83	.72
	2	1.67	.84	.66
	3	1.54	.80	.63
		1.61	.83	.67
Plant 3	1	1.66	.85	.67
	2	2.32	1.13	.81
	3	2.05	.93	.71
		2.01	.90	.73
Range		1.45-2.32	.80-1.13	.53-.81

TABLE 6. Ratios of COD, TVS, and TSS to BOD_5 in water from the final plant effluent stream in three broiler processing plants

		$COD:BOD_5$	$TVS:BOD_5$	$TSS:BOD_5$
Plant 1	1	1.65	.80	.79
	2	1.31	.70	.53
	3	1.65	.77	.66
		1.54	.76	.66
Plant 2	1	1.66	.94	.84
	2	1.60	.79	.63
	3	1.51	.73	.45
		1.59	.82	.64
Plant 3	1	1.09	.90	.77
	2	1.96	.88	.74
	3	1.36	.50	.46
		1.47	.77	.66
Range		1.09-1.96	.50-.94	.45-.84

TABLE 7. Average ratios of analytical procedures from evisceration screen, feather screen, and final plant effluent (FPE) from three broiler processing plants

	Evisceration	Feather	FPE
$COD:BOD_5$	1.67	1.80	1.55
$TVS:BOD_5$	0.83	0.90	0.77
$TSS:BOD_5$	0.76	0.68	0.65
TSS:TVS	0.92	0.76	0.84

TABLE 8. Treatment of broiler processing evisceration wastewater by gravity separation or polymer flocculation.

	BOD_5[a]	COD	TVS	FOG
Evisceration Wastewater	1524	3950	1656	1628
Gravity Separation	950	1945	697	364
% Reduction	38	50	58	78
Polymer Floculation	325	593	291	35
Reduction	79	85	82	98

[a]mg/L

CONCLUSIONS

From data presented in this paper, it is evident that both the concentration and characteristics of components of a wastestream vary constantly. Examination of the wastestream should be based on multiple composited sampling rather than from grab sampling.

The present study demonstrates that BOD_5 may be generally predicted from parameters which have the advantage of a shorter analytical time frame. The parameters utilized in this study were COD, TVS, and TSS. It must be stressed that, as shown here, a wide variability exists between different plants and that, in order to increase the accuracy of prediction, a substantial number of samples specific to a particular plant should be taken before confidence may be given to the predicted ratio.

Analysis of TVS to FOG ratios in a single sample of evisceration wastewater suggests that the FOG to TVS ratio may affect the BOD_5 to COD ratio. Additional data should be collected to confirm this observation.

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WASTEWATER TREATMENT SYSTEM UPGRADE AT A PROCESSING PLANT

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The wastewater pretreatment system at the Campbell's Douglas plant was experiencing difficulty in consistently meeting the municipal discharge standards of the city of Douglas, 300 mg/L biochemical oxygen demand (BOD) and total suspended solution (TSS) and 100 mg/L fat, oil, grease (FOG). The city was concerned that excessive organics discharged to the publically owned treatment works (POTW) would cause the treatment plant to be out of compliance with its discharge limits. To insure that the Campbell Company would be in strict compliance of the municipal discharge criteria, the company instituted a series of wastewater studies to determine the characteristics of the waste stream and based on this characterization select a pre-treatment system that would insure compliance.

PLANT DESCRIPTION

The Campbell's Douglas plant slaughters mainly heavy male broiler. The processed broilers along with other chicken products brought in from other sources are water cooked to produce deboned meat and chicken broth.

The original wastewater pre-treatment system consisted of a grease separation wheel to remove floating grease from the waste stream, primary and secondary trickling filters and clarifier to remove biological solids. biological solids were further digested prior to being land filled. Excessive FOG was blinding the media of the trickling filters so that they could not produce an effluent that would meet municipal discharge criteria. To assist in FOG removal, a flotation tank was installed to remove FOG from the cooking operation waste stream, however, the flotation tank did not remove enough FOG to solve the trickling filter problem.

To insure that the Campbell Douglas plant was in strict compliance of all environmental requirements, the Campbell company contracted with CH2M Hill to:

1. Characterize Campbell's wastewater.

2. Determine the efficacy of dissolved air flotation (DAF) pre-treatment either with or without chemicals using data supplied by Environmental Treatment Systems, Inc. (ETS).

3. Determine the capability of the existing wastewater treatment system.

4. Determine the most effective pre-treatment configuration for reliable compliance.

Characterization of the waste stream revealed that the plant discharged an average of 0.93 mgd. This wastewater contained an average of 1880 mg/L, 600 mg/L and 780 mg/L of BOD, FOG and TSS, respectively.

To determine the effectiveness of DAF pre-treatment with or without chemicals, ETS conducted the following tests.

1. Combined plant effluent, no chemicals.

2. Combined plant effluent, ferric sulfate and anionic polymer.

3. Combined plant effluent, acid and anionic polymer.

4. Cooking wastewater, no chemicals.

5. Cooking wastewater, ferric sulfate and anionic polymer.

These treatment methods revealed that air flotation of combined plant effluent without chemicals would remove 35 percent, 42 percent and 48 percent of BOD, FOG and TSS, respectively. Evaluation of the existing capacity of the trickling filter system predicted that the filters could consistently produce an effluent of less than 300 mg/L only when the in fluent to the trickling filters did not exceed 900 mg/L BODs and if sufficient FOG had been removed to prevent filter media blinding. Physical separation without chemicals of the combined plant effluent produced an effluent of 1740 mg/L BOD, well above the capacity of the trickling filters.

Physical separation without chemicals of the cooking wastewater would produce an effluent with a BOD of 720 mg/L, slightly below the design capabilities of the trickling filters.

DAF pre-treatment of combined plant wastewater using ferric sulfate plus polymer or acid plus polymer flocculation produced wastewater with a BOD of 440 mg/L and 780 mg/L, respectively. Both of these flocculation schemes produced an effluent above the municipal discharge criteria, however, the effluent was below the design capacity criteria of the trickling filters.

Based on these data, several configuration options were evaluated. The most feasible option was determined to be:

1. Addition of air to the flotation tank to increase recovery of non-chemically flocculated grease for rendering.

2. Installation of a chemical flocculated DAF downstream of the flotation tank to produce an effluent within the design capacity of the trickling filters.

3. Continue to use the trickling filters, as the third pre-treatment step to produce an effluent that was consistently below the discharge criteria of the city of Douglas.

Since this pre-treatment system was installed, the Campbell Company has been in compliance. During the past three years, the system has been out of compliance only two times and the resulting surcharge was less than $100. The success of the system upgrade was recognized in 1995 when the Georgia Water Pollution Control Association awarded the Campbell Company with its Industrial Pre-Treatment Award.

EVOLUTION OF A WASTEWATER TREATMENT SYSTEM AT A POULTRY FURTHER PROCESSING PLANT

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A poultry further processing plant has been in operation in a small town in north Georgia since the early 1980's. The facility was purchased from the original owners in mid 1980's by a major poultry processing firm. The processing plant has expanded many times over the years and the wastewater treatment operations have evolved to handle the increased loadings and meet the changing discharge requirements.

Seaboard Corporation acquired Elberton Poultry Company in mid 1980's and one of the many improvement to the facility was an upgrade of the wastewater treatment facilities. The existing wastewater treatment operations consisted of an anaerobic lagoon followed by a holding pond and a spray irrigation system. The treatment system was not adequate to properly treat the 35,000 gallons per day of wastewater that was being discharged. The wastewater had a biochemical oxygen demand (BOD_5) in excess of 1,500 mg/L and total suspended solids (TSS) of about 900 mg/L. There had been numerous odor problems and the irrigation system did not have the required land nor was it properly managed.

The first modification to the system involved discontinuing of the spray irrigation and installing a force main to discharge to the City's sewer system. Also, at this time the lagoon system was changed to include two anaerobic lagoons followed by an aerated lagoon and a polishing lagoon.

Within a couple of years, the systems were upgraded because the loading was exceeding the capacity of the system. This upgrade included the addition of fine screening, dissolved air flotation (DAF), and the addition of baffling and floating aerators in the first sections of the polishing lagoon. The fine screen and DAF were added to reduce the amount of oils and solids that were rapidly accumulating in the anaerobic lagoons.

This system worked well for several years but as the processing plant continued to expand and the wastewater flow and pollutant loading increased it began to stress the capability. In order to reduce the loading, the biological system, the DAF system was modified. To improve the efficiency of the DAF system, a chemical addition system was added in 1993.

In 1995, the flow to system was 100,000 gallons per day with peak flow of 450 gpm to the system. This was well in excess of the 150 gpm design capacity of the DAF. The latest upgrades to the system include the addition of a mixed flow equalization basin prior to the DAF and a higher capacity rotary screen.

The current discharge limits to the City are 150 mg/L BOD_5, 250 mg/L TSS, and 50 mg/L oil and grease. By continuously evaluating and making the needed modification to the wastewater system the company has maintained consist compliance while making maximum utilization of the system.

REAL TIME MONITORING OF A WASTEWATER TREATMENT SYSTEM

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This paper will review the use of online real time monitoring in contrast to conventional batch monitoring as related to a wastewater treatment system.

FUNDAMENTAL DIFFERENCES

There are numerous fundamental differences between online real time monitoring and conventional batch monitoring of a wastewater treatment system. One of the most obvious is the online monitoring operator interacts with the computer as events take place while the batch monitoring operator reports on events that have already transpired (Table 1).

TABLE 1. Comparing batch and online system standards

Characteristic	**Online**	**Batch**
Availability	Continuous	Scheduled Time Only
Response Time	Seconds	Hours
System Control	Multi-level	Single-level
Input Sources	Many	Few
Input Source Stream	Unrelated Types	Related Groups Only

[a]Rubin.

The data from an online real time monitoring system is readily available to the treatment system operator anytime, day or night. Whereas, a conventional batch monitoring system requires collection and analysis before the data is available to the treatment system operator. These collections are generally done on a scheduled basis.

An online real time monitoring system is capable of multitasking while a conventional batch monitoring system only handles one task at a time. A multitasking type system expedites the decision-making process which is an intricate part of the daily operation of a wastewater treatment system.

Response time is also an important factor of online real time monitoring. Many online real time monitoring system applications will have response times measured in milliseconds. Other commercial applications have response times between one and five seconds. In contrast, conventional batch monitoring systems information retrieval and analysis can take several hours.

In the world of wastewater treatment operation, conventional batch monitoring is "a way of life." In the past and currently, the majority of systems are operated using this method. The operator collects a grab or composite sample; the sample is analyzed for various parameters; and changes are made according to the results. The analytical results of the sample, the existing condition of the wastewater operating system and the necessary changes to the system are delayed. The amount of time that these parameters are delayed depends upon the frequency of the collection which can vary. These collections may occur every 30 minutes, 8 hours, 16 hours, or more. With the regulatory agencies requiring stricter compliances on the treatment systems effluent water quality, the conventional batch monitoring methodology is fast going by the wayside and online real time monitoring is becoming the standard.

However, online real time monitoring is not a new-comer to industry. Every wastewater treatment system is required to monitor the water flow through the system and to have a recording device that will continuously record the water flow. This allows the wastewater treatment system operator to observe the flow as it passes the sensing device in real time. The wastewater treatment system operator can readily observe any fluctuation of flow as it is happening. The flow meter with a recorder is one of the first online real time monitoring devices the wastewater treatment system operators were exposed to.

The new generation of information, data gathering, calculating and analyzing has placed the wastewater treatment system operator into the computer age. Today there are computer programs that allow the wastewater treatment system operator to monitor and automatically make adjustments to the wastewater treatment system while at home, attending short schools, conferences, symposimuns, etc. As the operation of a wastewater treatment system enters the computer age, it has become imperative that the new breed of wastewater treatment system operators be computer literate. Without the use and knowledge of a computer, understanding and interpreting the mass amounts of data that are collected by an online real time monitoring system will, more than likely, overwhelm and confuse the conventional wastewater treatment system operator.

In a typical industrial wastewater treatment system, there are numerous parameters that change instantaneously. In a conventional batch monitoring system, the wastewater treatment system could be experiencing symptoms of an upset condition long before the condition could be detected, either visually or analytically, thus delaying corrective actions. This type of operation is commonly referred to as a roller coaster operation. The online real time monitoring technique should alleviate these scenario.

BENEFITS

While there are multiple benefits derived from the implementation of an online real time monitoring system, most are difficult to measure quantitatively. Justification to management for an online real time monitoring system may have to be based on the systems ability to handle numerous functions at one time, the early detection of problems in the system, and the reduction in operating cost achieved through savings in energy cost. However, the direct and indirect benefits should be noted.

Direct Benefits

1. Administrative Cost Reduction - Direct benefits result when an online real time monitoring system performs a task formerly handled manually.
2. Efficiency Improvement - More direct benefit is realized when the online real time monitoring system increases the efficiency of the treatment system operation and reduces the total energy and chemical costs.
3. Improve Operation and Control - The online real time monitoring system results in increased management control, thus improving the operation of the system.
4. One-Time Savings - Implementation of an online real time monitoring system could lead to a one-time savings by avoiding the cost of expanding the present treatment system

through capitalizing on a more efficient utilization of the current treatment system.

Indirect Benefits

1. Management Process - Planning, control, resource allocation, etc. may be changed by the implementation of the online real time monitoring system.
2. Better Information - An online real time monitoring system will provide information not previously available without extended delays. This additional information would be instrumental in the decision-making process and result in an increase in efficiency of the treatment system operation and cost.
3. Long-Term Outcome - The online real time monitoring system may result in long-term benefits such as increased flexibility of management actions. Management can readily detect operational problems before they become critical and take necessary corrective actions. This task would be extremely difficult in a conventional batch monitoring system.

ANALYSIS OF ONLINE REAL TIME MONITORING

One of the major goals of any wastewater system operation is to maintain a steady state in the system. With online real time monitoring, the operation of the treatment system relies on operational problems being detected as soon as they occur, thus allowing the wastewater treatment system operator to make changes rapidly and maintain an optimal state condition.

TABLE 2. Typical hourly concentration changes

Ammonia	Dissolved Oxygen Demand	Energy Demand
Return Solids	pH	Respiration Rate
Settling Rate	Turbidity	Alkalinity
BOD	Water Flow	Wasting Rates

Before considering the installation of an online real time monitoring system at your facility, you must consider the following:

1. Do I have qualified personnel to operate an online real time monitoring system?

2. If not, where can they obtain the necessary training?
3. Where can the treatment system manager receive technical support?
4. What operating standards will need to be changed?

Next, the wastewater treatment system manager must consider what outputs (reports) will be required and how the reports will be formatted. Some common outputs for wastewater treatment systems are:

1. Totals, averages, maximums, minimums;
2. Time coding; and
3. Trending.

The wastewater treatment system manager must also consider the following during design:

1. Response Time - Response time is the length of time that elapses between the terminal transmitter and the terminal receiver. Normally, this time will be between a few seconds and a few minutes. The response time will be an important factor as it increases the Central Processing Unit's (CPU) ability to manipulate the data.
2. File Design - A tailored file structure, rather than the traditional design offered by an off-the-shelf computer software manufacturer, may be necessary to satisfy the file design. The faster the response time, the more critical the file design becomes. Therefore, traditional off-the-shelf software may not be appropriate.

The treatment system manager must identify the processing system (software program) that will produce the reports. There are numerous software companies that offer integrated packages. Make sure that the software program that you select is simple (user friendly), the software is flexible enough to allow expansion with minimum cost, and the software company is a stable company. These three factors will ensure your ability to meet any requirements in data collection and changes to your wastewater treatment system for years to come. Buyer beware! The least expensive software program can cost the end user more in the long term because the software company may not offer technical support or the software may not be capable of being modified to meet your future needs.

The next logical step is for the wastewater treatment system manager to define the inputs. The manager should address the following:

1. What data needs to be collected on an online real time basis? pH? Flow? Solids?
2. What hardware (computer, data storage unit, Uninterrupted Power Supply (UPS)) will the online real time monitoring system require?
3. Can these hardware components be easily upgraded at a reasonable cost?
4. What computer program will accept the input data, maintain the files, extract and edit reports?

When selecting the hardware necessary for monitoring the system, one important consideration is the compatibility of all of the devices. This is particularly important if it is necessary to purchase different components of the system from different vendors. For example, is the data collection system able to communicate with the central computer terminal? Will the CPU accept the signal transmitted from the monitoring device? Most sensors operate on a 4-20 MA signal that is sent from a transducer to the computer terminal. However, in this age of rapidly changing computer technology it is imperative at initial installation and for future upgrades that the compatibility issues are addressed.

WHY USE ONLINE REAL TIME MONITIRING?

A wastewater treatment system is a combination of processes put together to achieve desired end-results. Each of the processes that make up a treatment system must achieve a specified efficiency in order for the wastewater treatment system to obtain the desired end-results. It is currently very labor intensive to obtain constant, acceptable end-results when a conventional wastewater monitoring system is used. When online real time monitoring is employed on a wastewater treatment system, it does not take vacations, get sick, or fail to show up for work. The system can, at any given time, provide the status of all sensing devices, compile reports for a given time period, or provide up-to-the-minute analysis.

Some of the processes that make up a treatment system are:

1. screening;
2. primary treatment;
3. secondary treatment; and
4. system effluent.

As the wastewater is processed through the wastewater system, the water changes its characteristics based on the type of treatment it passes. In each of these processes, there are certain parameters that should be closely monitored and controlled to accomplish good treatment in a cost effective manner. They are as follows:

1. pH;
2. alkalinity;
3. solids;
4. dissolved oxygen;
5. flow rates;
6. liquid levels; and
7. chemical feed rates.

There are various means of saving money in a wastewater treatment system. One of the largest cost factors in the operation of a wastewater treatment system is energy. At some time, every wastewater system manager is asked how can the energy cost be reduced. With online real time monitoring, there are several ways this can be accomplished. The wastewater treatment system operator can control and monitor the system from anywhere a modem can be hooked-up. This allows for instantaneous changes to the system. Let's look at an example of a typical energy saving task using an online real time monitoring system (Figure 1).

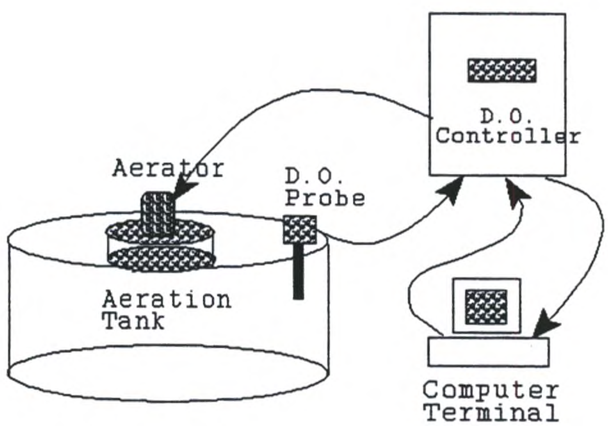

Figure 1. Controlling the dissolved oxygen level by online real time monitoring system.

Placing a dissolved oxygen probe in the aeration tank can help maintain the proper dissolved oxygen levels in the water thus reducing the energy cost. One horse power is equivalent to 0.745 KWH. Therefore, a 30 HP aerator uses 22.35 KWH. Using the average cost of $0.056 per KWH, a 30 HP aerator would cost $1.25 per KWH to operate. The cost of running an aerator is calculated by multiplying the Horse Power (HP) times Hours Run times 0.745 times Cost/KWH (HP*Hours Run*0.745*Cost/KWH). By utilizing an online real time monitoring system and controlling the dissolved oxygen level throughout the day, the energy savings for operating a 30 HP aerator are demonstrated in the table below.

TABLE 3. Energy savings for 30 HP aerator

Operating Hours/Day	KW/Day	Cost Savings/Day	Cost Savings/Year
24	536	NA	NA
20	447	$5.01	$1,828.65
19	425	$6.26	$2,284.90
18	402	$7.51	$2,741.15

CONCLUSION

Contrasting an online real time monitoring system with a conventional batch monitoring system demonstrates the improvements that can be obtained by converting to an online system. Increased sensitivity to the conditions of the wastewater treatment system, multitasking, reduced response time and administrative cost, improved efficiency, operation, decision-making and control can all be gained by implementing an online real time monitoring system. Design and analysis are critical to a successful conversion. Online real time monitoring is the future.

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TERTIARY SCREENING IN POULTRY WASTEWATER TREATMENT

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The poultry industry has long utilized screening to separate viscera and feathers from a facility's waste stream. Such separation allows the recovery of a plant's offal as a renderable by-product. Initially, and in some plants, still today only primary screening was employed. Typical sizing on primary screening is a 3mm opening (Tyler #6 mesh); theoretically no solids larger than this can pass through a primary screening system. Solids smaller than this are allowed to pass through the screens to subsequent treatment for removal. Commonly, such subsequent treatment includes dissolved air flotation (DAF) with chemical addition. In DAF's, these smaller solids are flocculated and floated to the tank surface. Solids recovered in this fashion typically are difficult to dewater, making recovery via rendering less attractive. Further, due to typical handling methods of these floated solids, and perhaps through adulteration via the use of certain chemical flocculants, the resulting float material is often a poor quality raw material for a subsequent rendering operation. In many cases, the float product is of such poor quality rendering is not an option and the product is land applied.

In recent years, the use of secondary screening has become more prevalent. A typical secondary screen has an opening size of 1mm (Tyler #16 mesh). Secondary screening offers several advantages. First, it allows recovery of offal solids prior to adulteration by chemicals. Further, with this additional mechanical separation of solids, fewer solids need to be recovered in subsequent treatment eg. DAF reducing the quantity of float produced and the quantity of chemicals utilized in the DAF. These factors have influenced many processors to install secondary screens.

Lately, a manufacturer has produced a tertiary screen claimed to be effective in the poultry industry. Sizing of the openings on the tertiary screen is available as low as 50 microns (.05mm, Tyler #270 mesh). Such screening, if effective, could dramatically increase mechanical recovery of solids. This, in turn, will decrease loading on subsequent treatment units, and reduce the demand for chemical additives for treatment.

Hudson Foods began production in July 1996, at a new poultry processing facility in Henderson, KY. This facility is equipped with primary, secondary and tertiary screens. This paper reviews the efficiency of the overall screening process at Henderson, with particular emphasis on the tertiary screen.

METHODS

The screening system at Henderson consists of two primary meat screens (0.125" or 3.2mm opening), two primary feather screens (0.125" or 3.2mm opening), followed by three secondary screens (0.040" or 1mm openings). After primary screening, meat and feather water are combined in a flume that feeds the secondary screens. Water passing through the screens flows by gravity to a 125,000 gallon equalization basin (EQB).

The tertiary screen requires a pressurized feed (20 psig min). Hence, secondary screened water is pumped from the EQB to the tertiary screens and/or the DAF's. Due to the unproven nature of the tertiary screen, a bypass around the screen was provided.

To determine screening efficiency, samples were collected at the following locations:

Sample Location Points

Meat Primary Screens Effluent
Feather Primary Screens Effluent
Secondary Screen Influent
Secondary Screen Effluent
Tertiary Screen Influent
Tertiary Screen Effluent
Tertiary Screen Fitrate

Grab samples were collected at each of these locations four times/day for a 1 week period. Samples were analyzed for the following constituents:

- COD (chemical oxygen demand)
- BOD (total suspended solids)
- TSS (biochemical oxygen demand)
- FOG (fat oil and greese)
- TKN (total kjeldahl nitrogen)

Additional data collection shall include tertiary screen influent flow rate, and volume of filtrate generated.

RESULTS, DISCUSSION AND CONCLUSIONS

(At press time, the tertiary screen had just begun operation. This section will be presented and distributed at the symposium).

NOTE: The secondary and tertiary screening systems installed at Henderson were Supplemental Environmental Projects undertaken pursuant to a Consent Decree entered by the U.S. District Court for the Southern District of Indiana in a civil action entitled United States v. Hudson Foods, Inc., Civil Action No. 1P93-0692-C.

POSTER PRESENTATIONS

THE USE OF POULTRY LITTER AS A SOURCE OF NITROGEN AND PHOSPHORUS FOR THE BIODEGRADATION OF PETROLEUM HYDROCARBONS IN CONTAMINATED SOIL

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Poultry production facilities are often concentrated within geographical areas to optimize efficiency of land utilization, buildings, equipment, personnel, and technology. Poultry litter (excreta plus wood shavings, sawdust or similar absorbent organic materials) produced in large quantities under these conditions is generally disposed of by land application to proximate pasture and cropland. When managed correctly, land application is a viable way to recycle nutrients contained in poultry litter. Pollution problems result when land application occurs under environmental conditions that do not favor agronomic utilization of nutrients such as the nitrogen, phosphorus, and heavy metals that may be contained in poultry litter.

Considering the current regulatory focus on agriculture, it is likely that the continued application of poultry litter onto land unable to utilize the nutrient loading is a limited option. To address this concern, management methods to ensure environmentally acceptable litter utilization require re-evaluation. Such methods include converting litter to "value-added" co-products for recycling as animal feedstuffs, compost for horticultural applications, or other uses. Due to its chemical, microbiological and physical characteristics, poultry litter is a potential co-substrate and source of nutrients for applications in the bioremediation industry. Bioremediation, the controlled use of microorganisms and nutrient amendments to catabolize hazardous compounds, has been an established technology for many years to treat soils and waters contaminated with petroleum compounds (Dean-Ross, 1987). The U.S. Environmental Protection Agency (EPA) has emphasized the use of bioremediation technologies for cleaning up soil sites contaminated with petroleum and other pollutants such as industrial solvents, and poly-chlorinated biphenyls (ASM News, 1991). One biotreatment application utilized for contaminated soil is ex situ (off site) "landfarming". This process is widely used for soils contaminated with petroleum hydrocarbon compounds.

Previous laboratory and field investigations have established that the success of soil bioremediation is often dependent upon supplementation of the contaminated soil with nitrogen, phosphorus, and oxygen (Thomas, 1989, Environment Today, 1992). Increased hydraulic conductivity, as well as increased nitrogen and phosphorus availability in soil as a result of applying poultry litter and animal manures to pasture and cropland has been documented (Khaleel et al., 1981, Westerman et al., 1988, Stewart, 1992). An increase in each of these parameters (hydraulic conductivity, nitrogen and phosphorus concentration) has been shown to optimize biodegradation, especially in soils high in clay content (Williams et al., 1992).

This study was conducted to evaluate the efficacy of poultry litter, utilized at varying concentrations, as an amendment for enhancing restoration of soil contaminated with high concentrations of diesel fuel.

EXPERIMENTAL DESIGN

The experimental design is shown in Table 1. Each biotreatment unit was comprised of a plastic tray (approximately 15 liter capacity) containing approximately 10 liters of soil contaminated with petroleum hydrocarbons. The contaminated soil (measured to contain approximately 4000 mg diesel fuel per kg) was procured from an actual site of an underground storage tank that had leaked for several years prior to its excavation. All biotreatment units were replicated 4X. Units 1, 2 and 3 were inoculated with equal amounts of petroleum-degrading bacteria (previously enriched from poultry litter). Poultry litter was added to Unit 1 such that the contaminant carbon:nitrogen: phosphorus ratio was equivalent to treatment levels recommended by the EPA for the evaluation and testing of protocols to determine the degradation potential of hazardous waste constituents in soil. Poultry litter was added to Units 2 and 3 such that the nitrogen and phosphorus concentrations were 10X and 20X more, respectively, as compared to Unit 1. Unit 4 contained no poultry litter and served as a control for quantification of abiotic reductions of the petroleum hydrocarbons. Each Unit was sampled weekly for total petroleum hydrocarbons. All analytical procedures were by approved EPA Methods.

TABLE 1. Experimental Design. Laboratory-scale evaluation of poultry litter as a co-substrate and source of microorganisms and inorganic nutrients for the biodegradation of petroleum compounds

Parameters	Unit 1	Unit 2	Unit 3	Unit 4
TPHC Contaminated Soil (4000 ppm)	Yes	Yes	Yes	Yes
1% Poultry litter	Yes	No	No	No
10% Poultry litter	No	Yes	No	No
20% Poultry litter	No	No	Yes	No
Petroleum degrading microorganisms	Yes	Yes	Yes	No
Moisture (15-20%)	Yes	Yes	Yes	Yes
Daily aeration	Yes	Yes	Yes	Yes

RESULTS AND DISCUSSION

Petroleum-degrading microorganisms were successfully enriched from broiler and turkey litter. The indigenous microorganisms were systematically challenged, over several weeks, with increasing concentrations of diesel fuel (100 mg/liter up to approximately 1000 mg/liter) contained in a liquid medium. A pooled culture, selected from broiler and turkey litter, was shown to utilize diesel fuel as its primary source of carbon and energy for growth and metabolism. However, the contaminated soil was shown to contain a diverse population of microorganisms. It is likely that these microbes, which were already adapted to the contaminated soil environment, would effectively catabolize the petroleum contaminants in the presence of adequate oxygen and inorganic nutrients.

The reduction of total petroleum hydrocarbons (TPHC) in soil supplemented with poultry litter is shown in Figures 1-3. A significant ($P<.0001$) first order rate of biodegradation was measured for all treatment units containing the broiler litter and enriched microorganisms as compared to the control unit (Figure 4) which contained no added litter or enriched microbes. TPHC removal from the control unit was measured to be 61% during the 5 week evaluation. However, it is noteworthy that prior to Day 28, very little reduction in TPHC concentrations had been measured in this unit (Figure 4). This is in contrast to the rapid rate of TPHC reduction that

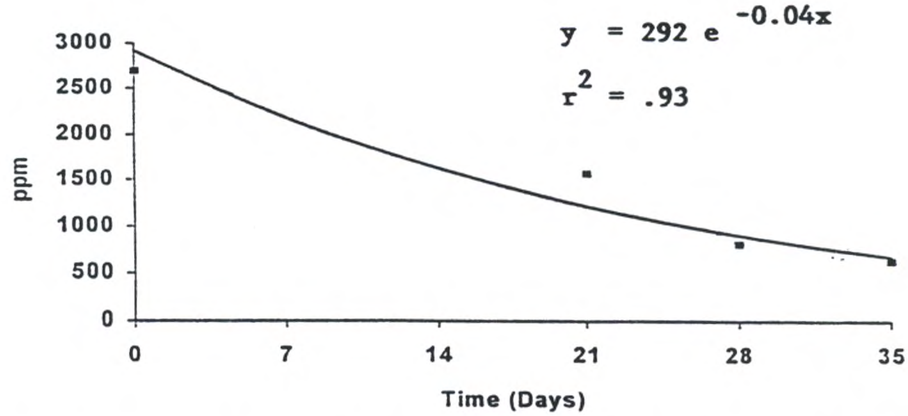

Figure 1. TPHC reduction in soil treated with poultry litter (app. 1% litter) and petroleum-degrading microorganisms

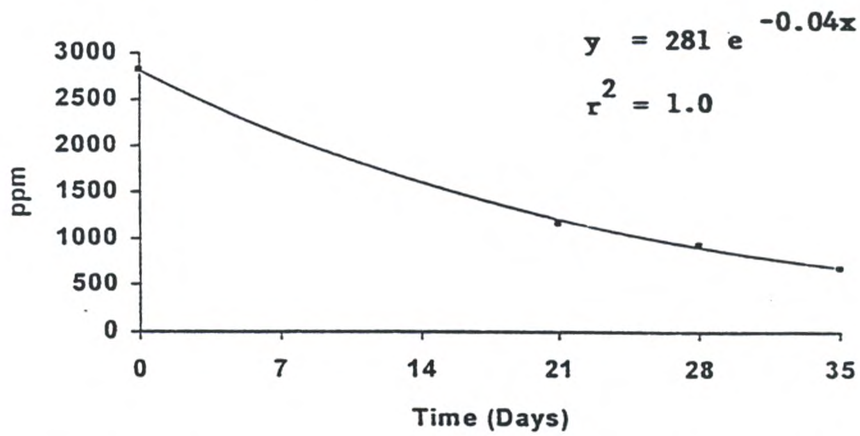

Figure 2. TPHC reduction in soil treated with poultry litter (10% litter) and petroleum-degrading microorganisms

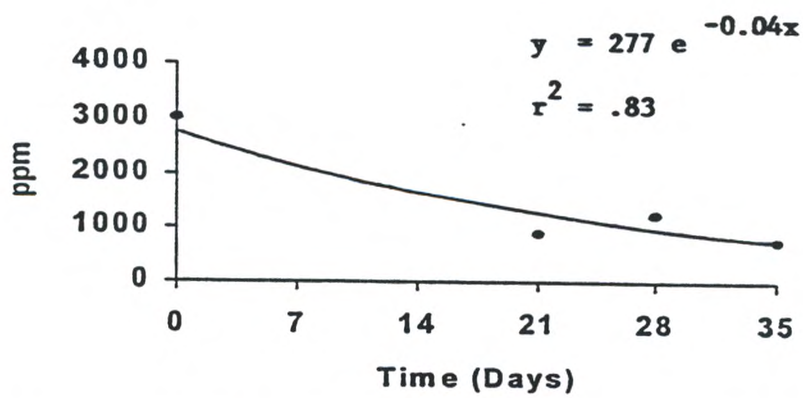

Figure 3. TPHC reduction in soil treated with poultry litter (20% litter) and petroleum-degrading microorganisms

occurred in all treatment units containing the poultry litter. No improved rate of TPHC reduction was observed due to increasing the concentration of poultry litter from 1% to 10 and 20% in the contaminated soil matrix. Considering the concentration of TPHC in the contaminated soil, as measured on Day 0, the 1% poultry litter supplement provided nitrogen and phosphorus such that the C:N:P ratio was approximately 100:5:1 as recommended by the EPA for biological treatment applications.

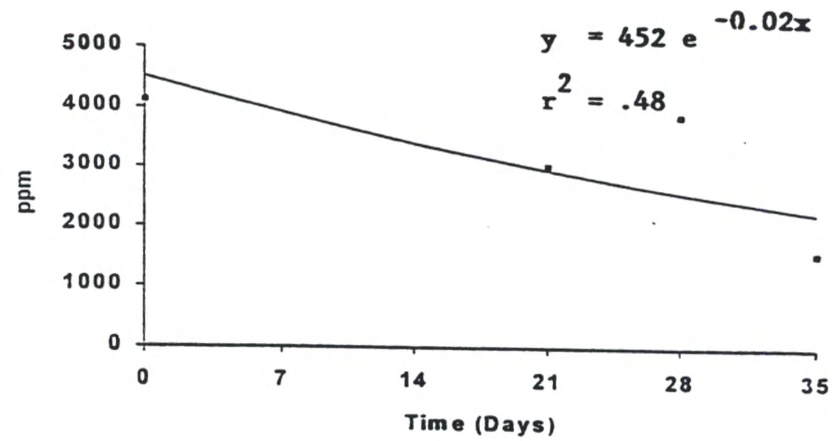

Figure 4. TPHC reduciton in soil treated with no poultry litter (control)

During the laboratory analysis, the treatment units were aerated daily by mixing the soil with a garden trowel. Oxygen is often the most limiting element for successful aerobic bioremediation and it is anticipated that the bulking capacity of poultry litter, as provided by higher that a 1% supplementation, may enhance TPHC remediation under commercial conditions in which daily tilling is impractical.

These results support the potential utilization of broiler litter as a source of nutrients for the bioremediation industry. This represents a niche market for removing poultry litter from areas of high production intensity where the build up of nutrients in the soils has been identified as an environmental concern for potentially impacting water quality. Plans are underway to test these variables under full-scale treatment conditions (the NC Department of Environment, Health and Natural Resources has granted the NCSU Animal and Poultry Waste Management Center permission to evaluate the use of poultry litter as a supplement for treating contaminated soil at a permitted commercial soil remediation facility located in NC).

SUMMARY

This study was conducted to determine the feasibility of utilizing poultry litter as a source of bacteria and limiting nutrients for the biorestoration of soil contaminated with approximately 4000 mg per kg (ppm) total petroleum hydrocarbons (TPHC) as diesel fuel. Biotreatment units containing contaminated soil, were supplemented (0%, 1%, 10% and 20% total weight basis) with broiler litter containing 3.65% nitrogen and 1.89% phosphorus. A significant first order rate of biodegradation was measured for all treatment units containing broiler litter. The results support the potential utilization of broiler litter as a source of nutrients for the bioremediation industry. This represents a niche market for removing poultry litter from areas of high production intensity where the build up of nutrients in the soils has been identified as an environmental concern.

ACKNOWLEDGMENT

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ISO 14000 FOR THE FOOD PROCESSING INDUSTRY

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In recent years, there has been an increase in environmental awareness around the world. This awareness led to the 1992 meeting of the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro. One direct result of this conference was the creation of the ISO Technical Committee 207 (TC 207). This TC was charged with the development of a series of environmental management and related standards which are known as the ISO 14000 family of standards.

The ISO 14000 family of standards will eventually consist of approximately 30 standards (Table 1). These standards will go beyond organizational evaluation and include product and process performance[1]. The ISO 14001 describes the elements needed to develop and Environmental Management System (EMS) (Table 1). ISO 14000 is the only standard that is auditable, and will be used in the proposed ISO 14000 registration process.

The ISO 14000 standards stress the following issues as they relate to environmental management:

Focus on processes.
Continuous improvement.
Maintaining the gains.
Preventing (rather than controlling) pollution.

[1]It should be noted that as of June 1, 1996, none of the ISO 14000 family of standards has been issued to final form by ISO. It is expected that ISO 14000, 14001 will be issued by the end of 1996.

TABLE 1. Elements of an Environmental Management System Model that is Based on ISO 14001

Element	Description of the element and list of required sub-elements
Policy	This element states that the organization's management is committed to the environment policy
Planning	This element ensures that the organization uses a systematic and logical approach to ensure the fulfillment of the commitment made in the environmental policy. Four sub-elements must be addressed: Environmental aspects Legal and other requirements Objectives and targets Environmental management program
Implementation and Operation	This section provides the mechanisms necessary to achieve policy, objectives, and targets. Seven sub-elements must be addressed: Structure and responsibilities Training, awareness and competency Communication EMS documentation Document control Operational control Emergency preparedness and response
Checking and Corrective Action	This element ensures that the EMA is built around the concept of continuous improvement. Four sub-elements must be addressed: Monitoring and measurement Nonconformance, and corrective and preventive actions Records Environmental management system audits
Management Review	This element ensures senior management is committed to the overall effectiveness of the EMS

A number of companies such as IBM, DuPont and Polaroid are incorporating environmental thinking in the organizational operations. The ISO 14000 standards provide the tools to accomplish this objective. These companies are embracing a strong environmental policy as a means to accomplish the following:

Decrease the risk of compliance costs
Reduce waste
Prevent pollution

Proactively anticipate changes in environmental regulations

Improve environmental performance

CONCLUSION

Food processing companies must address two separate issues regarding the use of the ISO 9000 standards to develop a quality management system. First, the company must determine if it is desirable to develop a quality management system that meets an appropriate ISO 9000 standard. Next, the company needs to determine if they should seek formal registration of the quality management system.

All food processing companies should have a quality management system that meets or exceeds either ISO 9001 or 9002. (It is not recommended that food processing companies develop a quality system to ISO 9003.) The ISO 9000 standards describe the minimum quality management system. Once this is accomplished, the food processing company must continue to improve the quality system by applying the principles of Total Quality Management (TQM)[2]. This allows the company to go beyond focusing on just meeting customer requirements to focusing on delighting the customer.

Obtaining formal registration is an economic question that executives must answer. Companies, which have achieved registration to an ISO 9000 standard, have received a number of benefits including increasing operational efficiency, profits, and sales. The average annual saving for each company that achieved registration has been estimated at $179,000 per year (CEEM, 1993). In addition to the internal benefits, these companies have achieved a number of external benefits as a direct result of obtaining ISO registration. These benefits include higher perceived quality, increased customer satisfaction, obtaining a competitive edge in the market and a decrease in the number of external audits. As of November 1995, 31 food processing sites in the United States and 15 sites in Canada have achieved ISO 9000 registration (Irwin Professional Publishers, 1995).

Food processing companies should consider adopting ISO 14000 as a model for an environmental management system. Currently, there is some anecdotal evidence that states when an EMS uses both a systematic approach and a continuous improvement approach to reduce pollution, improve the environment and

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[2]The criteria for the Malcolm Baldrige National Quality Award describe a basic framework for TQM.

reduce production costs. However, recommendations can not be made whether a company should seek registration of the EMS. Therefore, food processing companies should consider implementing an EMS but may want to delay the considerations of third party registration.

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POULTRY MORTALITY DIGESTERS--FIELD OBSERVATIONS

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There are several commonly accepted means of poultry mortality disposal available to the industry today. Each has its advantages and disadvantages. Disposal pits take little management ability, and are inexpensive to build and maintain, but can be polluting to the environment. Incinerators take little management skill, but are expensive to purchase, install and operate, and can be a source of olfactory distress throughout the neighborhood. Composters have caused a great deal of excitement within the industry during the last several years, but are expensive to build, and take substantial time and management skill. A system of picking up dead birds for rendering is being tried in eastern North Carolina, but proximity to a rendering plant and biosecurity concerns may limit its application. Fermentation as a means of limiting the degradation of a ground carcass is being tested in several locations. However, it is several years from wide acceptance, needs close cooperation with rendering, and takes a significant investment in dollars, time, and management skill.

The digestion process utilizes bacteria to degrade organic matter in a sealed dead bird digester system. The bacteria digests organic material and the mass is reduced by the venting of ammonia, carbon dioxide and water vapor. This process has been promoted as taking very little time and management skill for proper operation. Initial cost would put this system in a very competitive situation with a poultry mortality composter.

The Project

A grant was funded by the North Carolina Poultry Federation for monitoring some of these digesters as they were installed and used by the North Carolina poultry industry. Data was collected on number, age, weight and type of bird disposed in the poultry digester system. General observations of odor, fly presence, build up of sludge in the digester, intervals and amounts for the addition of water, and management problems were made.

Observations

The first system to be monitored consisted of two 1500 gallon tanks for dead bird disposal, and a 1000 gallon overflow tank. The system disposed of nearly 40 thousand pounds of poultry mortality during the initial year. A third 1500 gallon tank was installed to alleviate the problem of the system backing up on itself, during the final weeks of the flock cycle. This problem, of the system backing up on itself, seems to be characteristic of system as it is being promoted, and is indicative of the undersizing of the system in an attempt to minimize cost. One important factor in the success of this system will be the correct sizing of the system to accept all of the poultry mortality from a given farm.

Poultry mortality is opened by cutting through the abdominal skin, or cutting along the backbone of the bird. This increases exposure of the carcass to bacteria, facilitating digestion. Birds must be pushed under the solution in the tank at least once per day. This mixes the mass, keeps upper layers moist and provides access to these upper layers of the mass by bacteria in the solution.

Problems

Problems with the system (Table 1), at this point in the evaluation, stem from the amount of labor needed to open the dead bird, and mix the mass in the tank. Flies do not seem to be a problem, if the tanks are closed to access, and if the mass is turned adequately, allowing digestion of fly eggs and larvae. Odor is more musty than it is that of the rotting of flesh.

Making the System Work

Dead bird digestion technology is still in its early stages. It would appear that the process does work, but that the time and labor needed to open the body cavity of the bird and physically push the dead bird into the solution may limit the interest of some producers. Many problems may be inherent in the system, but by following certain procedures (Table 2), the process can be made to work more effectively.

TABLE 1. Problems observed with this system

1) Lack of quality control with bacteria. Sometimes several gallons of bacteria are needed before one actually starts the digestion process.

2) Companies selling system have based number of tanks on <u>average</u> daily flock mortality. During the last couple weeks of the flock life, there is insufficient capacity.

3) Sizing the system correctly may place the cost of the system too high for general acceptance by the industry.

4) Cutting the dead bird open, and pushing the mass under surface of the bacterial solution is more labor intensive than some other means of disposal.

5) If poultry mortality is not kept pushed below the surface, maggots will grow and flies can become a problem.

TABLE 2. Suggestions to aid performance

1) Open birds to allow access of bacteria to interior of the bird. Since this doubles the digestive surface, it increases the speed at which digestion takes place.

2) Push the birds below the surface of the liquid, periodically. This will speed up digestion as well as help eliminate maggots and odor.

3) Add water as needed. Water is the medium in which the bacteria live and reproduce, and digestion takes place.

4) A long time between flocks could cause the number of bacteria to decrease as the poultry mortality is used up, causing starvation of the population of bacteria.

5) Bacteriocidal compounds will kill the bacteria if introduced to the digester. Be careful that this does not occur.

6) Calculate the number of digester tanks needed based on 200 to 250 pounds of mortality per day per 1500 gallon tank. Use the maximum normally expected daily mortality during the last week of the flock as the base.

EXAMPLE:

Farm with 100,000 birds capacity, 7 pound birds at market, one percent mortality during last week of flock life.

100,000 birds X 1 percent mortality = 1,000 birds

1,000 birds X 7 pounds at market = 7,000 pounds

7,000 pounds / 7 days = 1,000 pounds per day

1,000 pounds/day / 200 to 250 pounds per tank = 4 to 5 tanks

CONCLUSION

Despite, its problems, dead bird digestion can work as an alternative to other types of poultry mortality disposal. More work needs to be done to improve the performance of mortality disposal as an alternative.

OPTIONS FOR POULTRY MORTALITY DISPOSAL

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Disposal of animal mortality is a problem for all livestock producers. To research new mortality disposal options and provide poultry growers information about existing alternatives, a committee of nine poultry growers and three company representatives from Harnett, Lee and Johnston counties in North Carolina was created in January 1994. Information was compiled about the costs, technology, and biosecurity considerations associated with six mortality disposal options (In-Ground Disposal, Incineration, Composting, Daily Route Pickup, Centralized Pickup, and Digestion). This paper summarizes information about cost estimates associated with these options.

METHODS

Net annualized mortality disposal costs were calculated for both straight run (7 week old birds) and split flocks (7 week old females and 11 week old males) for the 6 different options. The calculations assumed that the "straight run" broiler farm consisted of four 42'x 500' houses with a 112,000 bird capacity that averaged 5.5 flocks per year. The "split flock" broiler farm consisted of four 40'x 500' houses with a 108,000 bird capacity (50% male and 50% females) that averaged four flocks per year. The economic analysis format was modeled after a study completed by Crews et al. (1994).

Daily mortality numbers were collected from 15 straight run and 19 split flocks. Mortality weights were calculated by multiplying each day's mortality by the "Pilch Weekly Average Broiler Weight Standards". The mortality estimates used in the calculations were 81.53 lbs of mortality per 1,000 birds placed for straight run flocks. The split flock mortality estimates were 343.61 and 36.48 lbs of mortality per 1,000 males and females placed, respectfully.

The following provides a short explanation of each option and lists some of the assumptions used to calculate costs.

<u>In-Ground Disposal</u>. The system used in this cost analysis is commonly called the "grain bin" system. The upper 8 feet of a used grain bin is placed into the ground so the top extends above the ground. Mortality is placed in the bin via the lid.

- Each bin costs $450 installed.
- The "2 bin" system assumes that an operation installs two grain bins each year.
- The other two "in-ground" systems are based on recommendations of 50 ft^3 and 85 ft^3 per 1,000 bird capacity for straight run and split flocks respectfully (Wineland <u>et al</u>., 1987). The four house straight run and split flock farms would install 11 and 18 grain bins, respectfully. These systems last 8 years.

<u>Incineration</u> Incinerator style and costs were based on the types available in the Lee/Harnett/Johnston county area.

- Incinerator cost was $2,500 with a 5 year life.
- Fuel consumption was 0.083 gallons per pound of mortality (Wineland, 1987).
- The cost of propane was $0.62 per gallon.

<u>Composting</u>. The system used in this budget was a conventional mortality composter, not a mini-compost system. Size requirements and operation were based on the recommendations of Carter <u>et al</u>., (1993).

- The size of the compost structure was as follows:

	Straight Run	Split flock
Compost Bins*	1,072 ft^3	1,255 ft^3
Compost Storage	1,072	1,255
<u>Straw and Litter</u>	640	640
Total	2,784	3,150

* both first and second stage bins.

- Investment cost was $9,000 and $11,000 for straight run and split flocks respectively (Parsons, 1995).
- A tractor was valued at $20 per hour of use.
- Labor was estimated to take 45 minutes and 1 hour per day for straight run and split flocks, respectfully.
- The recipe was 1 part mortality; 2 parts litter; and 1/10 part straw (on a weight basis).
- The cost of compost disposal (land application) and value of compost were $10 per ton.

Daily Route Pickup. The system used in this analysis is a daily pick up of mortality. Mortality is placed into a bin on a daily basis. The hauler comes by daily and delivers the mortality to a renderer, extruder, or other destination (Honeycutt, K.R., 1995). Several growers supply a concrete pad and containers for mortality.

- At least 10 growers participate in the program.
- The budget assumes a fee of $200 per month. The actual fee may range from $50 to $300 per month.
- Building and Equipment Cost:
  - Containers (4'x4'x40")--- $375
  - Concrete Pad------------- $175
  - Road ------------------- $200
  - Total ------------------ $750
- Mortality was valued at $0.005/lb delivered to a renderer.

Centralized Pickup. Farmers take their daily mortality to a centralized location. Mortality is placed in a dump truck, bin or dumpster. A hauler takes the mortality from these sites to a renderer, extruder, or other destination.

- The cost of each site ranges from $6,000 to $60,000 (Parsons, 1995). The budget assumes that 10 growers would sign up per site. An initial investment of $3,000 per grower would generate $30,000 to pay for constructing each site.
- The budget assumes a hauling fee of $100 per month.
- Mortality is worth $0.005/lb delivered to a renderer.

Digestion. The equipment needed for digestion consists of 1 specially constructed septic tank and 1 overflow tank. Daily mortality is collected, split open (with a knife) and placed into the primary tank. This tank contains semi-digested mortality, water, and a lactobacillus culture for digestion of the mortality. As the primary tank fills, overflow water flows into the secondary tank (via a pipe connecting the two tanks) (Burkhardt, 1995).

- There are no good references available about on-farm digestion. This is unproven technology.
- A four house farm (both straight run and split flocks) needs four digester tanks and one overflow tank at a cost of $8,400 installed.
- The inoculum cost about $150 per gallon and it requires two gallons per digester per year (Burkhardt, 1995).
- Each digester needs to be pumped once per year.
- The digester will last for 10 years.

RESULTS

The annual cost estimates for the 6 mortality disposal options are listed in Tables 1 and 2. These are cost estimates based on farms with four houses. In-ground disposal is the least expensive option listed.

The second least expensive option is daily route pickup followed by centralized pickup. To date, no one has offered daily route or centralized pickup to broiler producers in the Lee/Harnett/Johnston area. Daily route, however, is being offered to area swine and turkey producers. The primary concerns associated with the route pickup options in the Lee/Harnett/Johnston area relates to biosecurity, the travel distance between growers, the distance required to deliver the mortality to a renderer, and the value of poultry mortality to renderers.

Composting and incineration have similar net annualized costs, but different cost components. The primary cost of incineration is the cost of the fuel ($2,584 and $4,225 for straight run and split flocks, respectfully). The major cost of composting however is the investment and labor costs. Finally, the net annualized cost for on-farm digestion appears to be similar to composting and incineration. On-farm digestion is still unproven technology. However, with further research the investment cost and cost of inoculum may be reduced.

TABLE 1. Annual cost estimates of different mortality disposal systems

	In-Ground			Incineration	
Initial Investment	2 Bin	S/R	Split	S/R	Split
Bldg/Equip	$900	$4950	$8100	$2500	$2500
Life (years)	1	8	8	5	5
Annual Fixed					
Bldg/Equip	900	619	1013	500	500
Interest (10%)	45	248	405	125	125
Maint/Repair	5	25	41	13	13
Insurance	-	-	-	15	15
Ann Var Cost					
Fuel/Util	-	-	-	2584	4225
Misc (1% invest)	9	50	81	25	25
Labor	300	300	300	450	600
Total Cost	**1259**	**1241**	**1839**	**3712**	**5503**
Value of Byproduct	-	-	-	-	-
Net Cost	**1259**	**1241**	**1839**	**3712**	**5503**

S/R = Straight Run Flock Sp = Split Flock
Interest = Initial Invest ÷ 2 * Interest
Maint/Repair = 0.5% on investment
Insurance = 0.6% on investment
Misc. = 1% on investment
Labor = $6/hour and 300 days per year

TABLE 2. Annual cost estimates for different mortality disposal systems

	Composting		Pickup				On Farm Digest
Initial Invest.	S/R	Split	D/R		Cent		
Bldg/Equip	$9000	$11000	$750		$3000		$8400
Life (years)	10	10	2		10		10
Annual Fixed							
Bldg/Equip	900	1100	375		300		840
Interest (10%)	45	55	38		150		420
Maint/Repair	45	55	4		15		42
Insurance	54	66	-		18		50
Ann Var Cost							
Litter	502	821	-		-		-
Straw	126	205	-		-		-
Inoculum	-	-	-		-		1200
Machinery	857	1286	-		-		-
Disp/Trans	800	1300	-		600		400
Fee	-	-	2400		1200		-
Misc	90	110	8		30		84
Labor	1350	1800	300		900		900
Total Cost	**5174**	**7293**	**3124**		**3213**		**3936**
Value of Byproduct	800	1300	251	St	251	St	-
	-	-	410	Sp	410	Sp	-
Net Cost	4374	5993	2873	St	2962	St	3936
			2714	Sp	2803	Sp	

S/R = Straight Run Flock Sp = Split Flock
Interest = Initial Invest ÷ 2 * Interest
Maint/Repair = 0.5% on investment
Insurance = 0.6% on investment
Misc. = 1% on investment
Labor = $6/hour and 300 days per year

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DEMONSTRATING THE FEASIBILITY OF UTILIZING A POULTRY LITTER LEAF TRASH COMPOST SOIL AMENDMENT FOR HORTICULTURAL CROPS

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The integrated structure of the poultry industry has encouraged the concentration of production near the essential services of feed mill and processing plant due to the economic considerations of transportation. This has resulted in a geographic concentration of poultry manure and in some cases the quantity of manure nutrients is more than can be utilized locally by environmentally sound crop application.

One strategy to deal with the high geographic concentration of poultry manure is to develop "add on value" manure products. This would make it economically feasible to move the manure nutrients out of the concentrated area into other geographic areas or for different uses than traditional crop production which in turn would make environmentally sound utilization possible.

One well known technology that would produce an "add on value" product is utilizing poultry manure as a nitrogen source in producing good quality compost. This project was organized to demonstrate the feasibility of producing a compost from a mixture of poultry litter and leaf trash and using the compost for different horticultural applications.

PROCEDURE

The project was carried out in two phases. The first phase involved the actual composting of the litter and leaf trash. The second phase was using the compost from the first phase in different horticultural practices.

Composting Poultry Litter and Leaf Trash

Leaves were stored at a county landfill in the fall and the following summer divided into four equal windrows approximately 40 feet long x 5 feet high x 6 feet wide. Fourteen tons of broiler litter were added to one windrow (broiler litter + leaves), fourteen tons of turkey litter were added to the second windrow (turkey litter + leaves) and 800 pounds of urea were added to the third windrow (urea + leaves) with the fourth windrow having no additional nitrogen source (leaves). The windrows were then reshaped to original dimensions and turned weekly for the first two months. Internal windrow temperatures were recorded routinely through the first two months and periodically thereafter. All composts were analyzed for nutrients three months after the compost process.

Using Compost in Horticulture Demonstrations

Turf. Replicated demonstration turf plots were established in October utilizing the three compost treatments and the untreated leaf compost. Three inches of assigned compost were tilled into each plot in addition to following recommended liming and fertilization based on soil test. Evaluation of the different treatments included a visual index score, leaf analysis and soil analysis.

Ornamentals. An ornamental plant demonstration plot was established in April at the NCSU Arboretum using two types of poultry litter compost (turkey litter + leaf trash and turkey litter compost without added carbon source) and a chemical fertilizer treatment. Evaluation of ornamental planting included visual observation, plant growth and leaf analysis. This demonstration will be utilized in educational programs with landscapers and general public which are ongoing at the Arboretum and other extension programs.

RESULTS

Composting

Internal windrow temperature profiles varied widely for the different compost (Table 1). The urea + leaves began composting immediately reaching a peak temperature of 138°F within a week and then cooled to the mid 120°F range for several weeks and was only 60°F on January 9th. The broiler litter + leaves treatment reached 137°F in the fifth week and was 80°F on January 9th. The turkey litter + leaves compost reached 140°F in the sixth week and was 80°F on January 9th. The leaves compost reached a peak temperature of 126°F two weeks after the windrows were established and remained in the low 120° range through eight weeks with the window temperature at 100°F on January 9th.

TABLE 1. Poultry litter leaf trash compost temperatures compost started 7/11/94

Treatment	Peak Date	Peak Temperature	October Temperature	January Temperature
Leaves	8/24/94	126°F	120°F	110°F
Urea + Leaves	8/17/94	138°F	125°F	60°F
Broiler Litter + Leaves	9/20/94	137°F	130°F	80°F
Turkey Litter + Leaves	9/20/94	137°F	130°F	80°F

Table 2 shows the nutrient analysis of the three compost treatments and the leaf control. Moisture levels were higher in the two treatments not containing poultry litter. As one would expect, the nitrogen was twice as high in the urea and poultry litter treated compost. The phosphorus and potash values were dramatically higher for the broiler litter + leaves and turkey litter + leaves treatments.

TABLE 2. Nutrient analysis poultry litter leaf trash compost

Treatment	Dry Matter %	N%	%P	%K
Leaves	47.67	1.25	0.10	0.16
Leaves + Urea	46.20	2.15	0.10	0.18
Leaves + Broiler Litter	52.92	1.94	1.24	1.11
Leaves + Turkey Litter	54.81	2.77	1.15	2.08

Demonstrations

Fescue Turf Plots. Dramatic differences among the turf plot treatments could be seen as early as December which was two months after seeding. The fescue grass in the leaf compost treatment with no nitrogen added and the control plots with no compost added were less hardy and less green. The plots were visually scored in March, May and August based on ground cover, vigor, thickness, and color. The visual index scores on a 1 to 10 score are shown in Table 3. The fescue in the plots of compost with a nitrogen source had higher visual index scores in March and May. A drought in July and August damaged all the plots resulting in a very poor fescue stand in all plots which are reflected in the August index scores. The plots were reseeded for further analysis the upcoming growing season.

TABLE 3. Average fescue plots visual index scores[1]

Date	Control No Compost	Leaves Compost	Urea + Leaves Compost	Turkey Litter + Leaves Compost	Broiler Litter + Leaves Compost
3/20/95	4	4	7	8	6.5
5/30/95	3	4	8	6.5	7
8/04/95	1	1	1	1	2

[1]Index: 0-10 which is an average of scores of ground cover, vigor, thickness, and color with 10 = perfect and 1 = poor.

Grass leaf analyses were conducted on samples in May and the results are listed in Table 4. The leaf analyses indicate a deficiency in nitrogen for the plots that had no compost or the leaf compost with no nitrogen added. Other differences among treatments could be seen which generally follow the same trend indicating less nutrient uptake by the grass in the plots that had no compost or the plain leaf compost.

Ornamental Demonstration. All ornamentals established well with only one shrub not making it through a late spring dry period. To date, no difference could be seen in the plantings among treatments during the first growing season except the ornamentals were observed to be greener in the plots where the plain turkey litter compost was added.

TABLE 4. Average interpretation index of fescue leaf analysis

Measure-ment	Control No Compost	Leaves Compost	Urea + Leaves Compost	Turkey Litter + Leaves Compost	Broiler Litter + Leaves Compost
N	22(D)	21(D)	48(L)	38(L)	29(L)
P	56	54	63	72	70
K	28(L)	31(L)	42(L)	52	40(L)
Fe	36(L)	40(L)	51	51	48(L)
Mn	72	70	100	86	89
Cu	42(L)	43(L)	49(L)	54	48(L)
Zn	52	54	56	54	56

(D) = Deficient
(L) = Low

WEST VIRGINIA POULTRY PRODUCTION SURVEY: A REPORT ON THE IMPLEMENTATION OF WATER QUALITY IMPROVEMENT PRACTICES IN THE FIVE EASTERN PANHANDLE POULTRY PRODUCING COUNTIES

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Over the past five years, the West Virginia poultry industry has undergone considerable expansion within the Potomac River Watershed, becoming the predominant agricultural industry within the state. The rapid expansion of the poultry industry, combined with West Virginia's established beef cattle industry, has generated questions concerning the affects of the large number of animals on water quality within the watershed. A survey was conducted to determine the level of Best Management Practice (BMP) implementation in order that educational and technical programming could be targeted toward specific BMPs in need of further attention.

SURVEY RESULTS

The following data and discussion represent selected results from the original 55 question survey. The surveys were distributed to 375 poultry producers. Producers returned 199 surveys, representing 53% of the population. A full version of the study is available upon request.

Land Utilization

Table 1 depicts the different land use catagories on West Virginia poultry farms. With only 2% of farm land in row crops, nutrient loading on crop land needs to be monitored closely to prevent or control excess nutrient application. With grassland and hay acreage as the predominant land use category, educational programming concerning the appropriate use and application of litter on this land use is critical.

Producers with less than 50 acres sell an average of 81% of their litter. Producers with greater than 50 acres sell an average of 33% of their litter. This redistribution is an important BMP currently being implemented.

TABLE 1. Poultry farm land use categories

Response	No. of Responses[a]	% of Total Responses
Timber	26	23.8 (± 4.1)
Row crops	4	2.1 (± 1.7)
Grassland/Hay	158	84.0 (± 4.4)

[a]n=188

Litter Storage and Land Application

Due to cost share programs, litter sheds are now a common method of litter storage, accounting for 37% of the litter storage systems in the watershed (Table 2). Open pile storage is traditional, but not environmentally sound. Uncovered litter, even for short periods of time, has the potential of becoming a source of nonpoint pollutants. Covering litter with a tarp during winter or for short periods in the field must become an integral part of a litter utilization plan for all poultry litter users.

TABLE 2. Litter storage systems

Response	No. of Responses[a]	% of Total Responses[b]
Litter Shed	64	36.2 (± 6.1)
Under Tarp	20	11.3 (± 4.0)
Open Pile	52	29.4 (± 5.8)
Other	41	23.2 (± 5.4)

[a]n=177

Thirty eight percent of producers have fan-type spreaders while 65% have box-type spreaders. The box-type spreaders are designed to apply semi-solid livestock manures and tend to over-apply poultry litter. The fan-type spreaders apply litter more evenly and allow for reduced loading rates on pasture and hay land. The 65% of producers who use box spreaders could improve litter utilization with slow-down kits that reduce application rates. Sixty percent of producers have calibrated their equipment. The 40% of producers who have not calibrated their equipment need to do so to quantify litter loading rates as an integral component of a nutrient management plan.

Litter application is predominantly a spring and fall activity (Table 3). The timing of these applications fit with BMPs that include applying litter before planting corn in the spring and fall applications of litter on pasture and hay ground. Fall applications promote winter root reserves (Rayburn et al., 1979;) while winter applications have the greatest potential to impact the environment due to the lack of plant growth and nutrient uptake during that time of year (Young and Mutchler, 1976).

TABLE 3. Timing of litter applications

Response	No. of Responses[a]	% of Total Responses
Spring	127	78.9 (± 5.3)
Summer	44	27.3 (± 5.8)
Fall	115	71.4 (± 5.8)
Winter	41	25.5 (± 5.6)

[a]n=327 (reflects multiple answer selection)

Agronomic Management

Sixteen percent of producers who raise corn use the pre-sidedressed nitrate-nitrogen soil test (PSNT). Demonstrations that show the nitrogen savings from using PSNT need to be continued. Producers who use repeated applications of litter on corn fields need to account for the organic nitrogen fraction that becomes available during the second and third year after application (Magdoff et al., 1984).

Fifty seven percent of producers were establishing small grain cover crops on some or all of their crop land during the winter months (Table 4). Small grains are best suited to scavenge soil nitrogen residuals or fall applied nitrogen found in litter or manures. Poultry litter applications commonly occur on corn ground after harvest. The establishment of cover crops is crucial to trap the available nitrogen fraction contained in the litter.

TABLE 4. Percentage of fields managed with a cover crop

Response	No. of Responses[a]	% of Total Responses
0%	41	42.7 (± 8.3)
1 to 25%	19	19.8 (± 6.7)
26 to 50%	8	8.3 (± 4.6)
51 to 75%	3	3.1 (± 2.9)
76 to 100%	25	26.0 (± 7.3)

[a]n=96

Nutrient Analysis

Thirty three percent of producers test their litter for fertilizer value. To improve utilization of litter and as a component of a nutrient management plan, all producers should have their litter tested periodically to determine its nutrient content. Producers who sell their litter would improve its marketability by quantifying the nutrient value of the litter prior to sale. Soil testing is an under-utilized agronomic decision making tool, as shown in Table 5. Nutrient management plans require a soil sample from every field at least once every three years.

TABLE 5. Percentage of fields soil tested every 3 years

Response	No. of Responses[a]	% of Total Responses
0%	50	36.2 (± 6.7)
1 to 25%	14	10.1 (± 4.2)
26 to 50%	12	8.7 (± 3.9)
51 to 75%	5	3.6 (± 2.6)
76 to 100%	57	41.3 (± 6.9)

[a]n=138

The majority of producers (61%) rely solely on litter for their nutrient needs (Table 6). These applications of litter are presumably being applied to meet the nitrogen needs of crops and forages. Phosphorus build up may occur on these fields that receive repeated litter applications.

TABLE 6. Nutrient needs met by commercial fertilizer

Response	No. of Responses[a]	% of Total Responses
0%	86	61.4 (± 6.7)
1 to 25%	37	26.4 (± 6.1)
26 to 50%	12	8.6 (± 3.9)
51 to 75%	2	1.4 (± 1.6)
76 to 100%	3	2.1 (± 2.0)

[a]n=140

Thirty four percent of poultry producers stated that they have a nutrient management plan. In order to demonstrate proper utilization and distribution of poultry litter and livestock manures, all producers need an effective nutrient management plan.

Mortality Management

Do to cost-share and educational programming, composting has become increasingly accepted as the mortality utilization method of choice (Table 7).

TABLE 7. Mortality management systems

Response	No. of Responses[a]	% of Total Responses
Compost	74	37.1 (± 5.7)
Render	64	32.2 (± 5.5)
Incinerate	7	3.5 (± 2.2)
Burial Pit	42	21.1 (± 4.8)
Other	12	6.0 (± 4.8)

[a]n=199

The survey results also indicated that there is a high approval rating associated with composting, with 95% of producers that currently compost satisfied with the system.

CONCLUSIONS

Improved methods of poultry litter storage, application, and increased litter distribution are occurring. Poultry mortality management has made a steady shift toward composting. Producers need further education on how they can maximize poultry litter as a fertilizer. Overall, poultry producers are showing increasing commitment to voluntary land stewardship which will improve the sustainability of the poultry industry within the West Virginia Potomac Watershed.

Conclusions drawn from these data which need to be acted upon by educational and technical agencies and by poultry litter users are as follows:

1. Pasture and grass hay land are the largest treatable land use categories. Programs need to be developed to improve the acceptability and utilization of litter as a fertilizer source for pasture and hay land.
2. Litter stacked for even a short duration needs to be covered. Producers selling litter need to promote proper litter storage methods with litter buyers.
3. Soil testing and litter/manure analysis need to be a standard activity for all producers in order for them to develop site-specific nutrient management plans.
4. A winter cover crop program needs to be initiated to reduce soil erosion and the loss of nutrients during the winter months.

5. Agencies and integrators need to cooperatively eliminate burial pits as a mortality management system. Composting needs to be promoted as the best on-farm method.
6. The PSNT test needs to be promoted to improve producer acceptance of test results and subsequently improve the utilization of litter applied to corn ground.

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RECOVERY AND UTILIZATION OF VALUABLE COMPONENTS FROM EGG PROCESSING WASTEWATER

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The egg industry has been estimated to generate more than 2.5 billion gallons of wastewater (WW) annually which are routinely discharged to municipal sewage treatment systems. These WW typically carry high organic loads attributed to substantial amounts of egg proteins and fats (Carawan et al., 1979). High concentrations of these organic components in wastewater streams remain a serious problem for the industry in terms of water pollution concerns, product losses, and increasing municipal sewer surcharge rates. Those organic components lost in the WW have potentially high nutritional and economic value. Therefore, recovery and utilization of such components from egg processing WW may reduce wasteloads, allow recycling of reconditioned WW, and permit recovery of egg solids for use in livestock feeds or other applications. One approach to achieve these goals is by employing a chemical precipitation/coagulation technology with coagulants such as lignosulfonate (LSA), bentonite (BEN), carboxymethylcellulose (CMC), and ferric chloride ($FeCl_3$). The objectives of this study were to (1) evaluate the effectiveness of this by-product recovery technology on egg processing WW and, (2) utilize compositional analyses to determine the potential of using recovered egg solids for use in animal feeds.

MATERIALS & METHODS

Wastewater Samples

Wastewater samples were collected from two different commercial egg processing plants. In addition, simulated egg wastewater samples (SWW) were also prepared (0.5% w/v, liquid whole egg in tap water).

Experimental Procedures

In preliminary investigations, supernatant quality based on maximum COD removal and turbidity reduction was used to screen and select coagulants and optimize treatment conditions. Based on these preliminary studies, four coagulants (LSA, CMC, BEN, $FeCl_3$) which were purchased from Fisher Scientific Co. were selected for further study. Two hundred ml jar-tests were conducted at WW temperatures of 22-25oC. The procedure began with pH adjustment (pH range of 2.5 - 9) of WW using 1 N H_2SO_4 and/or NaOH, followed by addition of a single coagulation agent at ten different concentrations (100-1000 mg/L), mixing for 1 min at 100 rpm and 3 min at 40 rpm, settling for 30 min, and a final centrifugation step (1,464 x g for 5 min). Samples taken before and after treatment were analyzed for chemical oxygen demand (COD), total suspended solids (TSS), turbidity, protein, and fat. Recovered egg solids were dried in a drying oven at 70°C and analyzed for protein, fat, and ash contents. The analytical methods followed those described in Standard Methods for Water and Wastewater Analysis (APHA, 1994). All experiments were replicated three times.

RESULTS AND DISCUSSION

Our findings indicated that the removal of COD, TSS, and turbidity from egg processing WW using precipitation/ coagulation technology was pH dependent (Tables 1-4). The optimal pH values for achieving maximum removal efficiencies with LSA, CMC, $FeCl_3$, and BEN were 3.5, 3.0, 8.0, and 4.0, respectively. The effects of mixing time were also investigated and were based on COD and turbidity reductions. The highest reductions were achieved when mixed for 1 min at 100 rpm, followed by 3 min at 40 rpm. The optimal coagulant dosages strongly depended on the WW sources, coagulant type, total WW solids, and initial concentrations of protein and fat. Under optimal treatment conditions, the COD reductions for LSA, CMC, $FeCl_3$, and BEN were 90 - 95% (average: 92%), 80 - 95% (average: 87%), 80 - 91% (average: 86%), and 92 - 97% (average: 94%), respectively. In terms of COD removal, all coagulants performed within the range of removal efficiencies previously reported by Beszedits (1982) for treatment of dairy, meat, and poultry processing WW. However, LSA and BEN achieved greater COD removal than CMC and $FeCl_3$. The COD removal using CMC and $FeCl_3$ were over 90% from WW of plant A and SWW but only 80% from WW of plant B. This finding may be attributed to the differences in the organic constituents of the WW. In plant A, only egg washing and breaking lines were operated. Whereas, plant B included these operations plus further processing (i.e. cooking operations). Thus, it may have been more difficult to treat this type of egg processing WW by chemical precipitation/coagulation due to the presence of more denatured proteins from the further processing lines.

TABLE 1. The removal efficiency using LSA (pH = 3.0)

Samples	LSA (mg/l)	COD (mg/l)	% COD Removal	TSS (mg/l)	% TSS Removal	Turbidity (FTU)	% Turbidity Removal
Plant A	500	6,120	94	2,680	99	2,100	97
	1,600	13,570	91	4,150	97.6	4,150	99
Plant B	1,000	4,805	90	1,856	99	2,710	98.5
	700	4,100	90	900	99	1,700	99
MWS	1,000	4,795	95	588	98	1,190	97.6

TABLE 2. The removal efficiency using CMC (pH = 3.0)

Samples	CMC (mg/l)	COD (mg/l)	% COD Removal	TSS (mg/l)	% TSS Removal	Turbidity (FTU)	% Turbidity Removal
Plant A	300	6,120	95	2,680	98.6	2,100	98
	1,000	13,570	9189	4,150	97.8	4,150	99
Plant B	200	4,805	9083	1,856	99	2,710	99
	200	4,100	80	900	99	1,700	99
MWS	400	4,795	90	588	97.9	1,190	97.6

TABLE 3. The removal efficiency using $FeCl_3$ (pH = 8)

Samples	$FeCl_3$ (mg/l)	COD (mg/l)	% COD Removal	TSS (mg/l)	% TSS Removal	Turbidity (FTU)	% Turbidity Removal
Plant A	100	6,120	90	2,680	97.5	2,100	97
	200	13,570	86	4,150	97	4,150	98.5
Plant B	200	4,805	83	1,856	99	2,710	99
	300	4,100	80	900	99	1,700	99
MWS	100	4,795	91	588	97.5	1,190	98

TABLE 4. The removal efficiency using bentonite (pH = 4.0)

Samples	Bentonite (mg/l)	COD (mg/l)	% COD Removal	TSS (mg/l)	% TSS Removal	Turbidity (FTU)	% Turbidity Removal
Plant A	800	6,120	97	2,680	98.7	2,100	99
	2,500	13,570	94.5	4,150	97.6	4,150	99
Plant B	1,400	4,805	92	1,856	99	2,710	99
	1,600	4,100	92	900	99	1,700	99
MWS	1,200	4,795	93	-	-	1,190	98

TSS and turbidity reductions for egg processing WW were independent of coagulant type and wastewater source and consistently were over 97.5%. Final TSS concentrations and turbidities were below 20 mg/L and 10 formazin turbidity units (FTU), similar to that of drinking water (EPA, 1977). Thus, it is possible that these recovered supernatants could be recycled for further use in washing equipment and floors following chlorination.

Precipitates were collected and dried in a drying oven at 70°C and the resulting egg solids were analyzed for protein, fat, and ash contents. Protein and fat recovery efficiencies were similar to that of COD reductions and depended on the wastewater sources, coagulant type, and initial concentrations of protein and fat (Tables 5-8). Our results indicated that 26 to 110 pounds (12 to 50 kg) of dried by-products per 1,000 gallons (3,785 L) of WW could be recovered by using these chemical precipitation/coagulation techniques. These precipitates contained high concentrations of protein (36 - 50%), fat (32 - 42%), and ash (2 - 27%). Ash contents were relatively high in the solids recovered by the FeCl3 and BEN coagulants because $FeCl_3$ is an inorganic compound and BEN contains high concentrations of inorganic compounds and thus both would contribute to the total ash content.

TABLE 5. Egg solids recovery and compositions of egg solids using LSA

	Protein (mg/)	Protein % Recovery	Fat (mg/l)	Fat % Recovery	Solids (g/gal.)	Compositions of Egg Solids: Protein %	Fat %	Ash %
Plant A	1,944	95	1,796	96	30.4	50	39	4
	4,313	91	3,892	92	51.4	42	34	8
Plant B	1,446	91	1,340	92	14	36	34	2
	1,280	90	1,132	92	-	-	-	-

TABLE 6. Egg solids recovery and compositions of egg solids using CMC

	Protein (mg/)	Protein % Recovery	Fat (mg/l)	Fat % Recovery	Solids (g/gal.)	Compositions of Egg Solids: Protein %	Fat %	Ash %
Plant A	1,944	92	1,796	92	28.8	50	42	4
	4,313	90	3,892	90	47.7	42	34	9
Plant B	1,446	86	1,340	87	-	-	-	-
	1,280	81	1,132	82	-	-	-	-

TABLE 7. Egg solids recovery and compositions of egg solids using $FeCl_3$

	Protein (mg/)	Protein % Recovery	Fat (mg/l)	Fat % Recovery	Solids (g/gal.)	Compositions of Egg Solids		
						Protein %	Fat %	Ash %
Plant A	1,944	92	1,796	92	28.8	50	39	8
	4,313	90	3,892	90	47.7	42	34	19
Plant B	1,446	87	1,340	87	-	-	-	-
	1,280	81	1,132	82	-	-	-	-

TABLE 8. Egg solids recovery and compositions of egg solids using CMC

	Protein (mg/)	Protein % Recovery	Fat (mg/l)	Fat % Recovery	Solids (g/gal.)	Compositions of Egg Solids		
						Protein %	Fat %	Ash %
Plant A	1,944	95	1,796	96	29.9	39	32	24
	4,313	90	3,892	90	43.5	37	35	26
Plant B	1,446	93	1,340	94	12.6	36	34	27
	1,280	92	1,132	92	-	-	-	-

All coagulants tested in this study are considered as safe for food processing applications and have been extensively used in the food industry (i.e. CMC as a texture builder for ice cream, LSA as a binder, $FeCl_3$ as a nutrient, and BEN as a clarifying agent in beer; Furia, 1980). Broiler chick feeding trials using these coagulants indicated no adverse effects (Cerbulis, 1978; Rusten et al., 1990). Therefore, the recovered egg solids are anticipated to be safe and have a high nutritional and economic value and may be useful as a livestock feed ingredient or for other purposes (ASAE, 1992).

In comparison with other available coagulants, those selected for this study, particularly LSA (by-product of the paper industry), BEN (type of soil), and $FeCl_3$, are relatively inexpensive. Although CMC is relatively expensive, the dosage required in this application is very low (below 300 mg/L). The cost estimated for one kilogram of LSA, BEN, $FeCl_3$, and CMC are $0.90, $1.95, $4.50, and $8.00, respectively.

CONCLUSIONS

1. In terms of COD, TSS, and turbidity reductions, the four coagulants evaluated in this study were similarly effective for treating egg processing plant WW and yielded recoverable solids high in protein and fat.

2. For the majority of egg processing wastewaters treated, the final TSS concentration and turbidity values were below 20 mg/l and 10 FTU, respectively, similar to that of potable water standards. Thus, the recovered supernatants have the potential to be recycled for use in washing equipment and floors following an initial chlorination step.

3. The four coagulants tested in this study were relatively inexpensive in comparison with other commercially available coagulants.

4. The findings from this study indicated that the probable recovery and utilization of such egg by-products by the coagulation/precipitation technology could reduce plant wasteloads, reduce municipal sewer charges and surcharge rates, allow recycling of reconditioned wastewaters, and permit recovery of egg solids for use in animal feeds or for other purposes.

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THE EFFECTS OF SODIUM BISULFATE ON POULTRY HOUSE AMMONIA, LITTER pH, LITTER PATHOGENS, INSECTS, AND BIRD PERFORMANCE

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Sodium bisulfate (SBS) is a dry granular acid used extensively by the poultry industry for poultry house ammonia control, litter acidification, and on-farm pest management and HACCP programs for pathogen reduction. SBS meets Food Chemical Codex Standards that ensure product safety and purity and SBS is manufactured under ISO 9002 standards that ensure consistent quality. A series of research trials were conducted at several independent universities to document the current usage of SBS in the poultry industry.

POULTRY HOUSE AMMONIA AND LITTER pH

The volatilization of ammonia has been attributed to microbial decomposition of nitrogenous compounds (Burnett and Dondero, 1969; Carlile, 1984), principally uric acid in poultry house litter. Litter pH plays a decisive role in NH^3 volatilization (Ivos <u>et al</u>., 1984). Once formed, the free ammonia will be in one of two forms: as the uncharged NH_3 species or the ammonium ion (NH_4), depending on the pH of the litter. Ammonia concentration increases with increasing pH (Carr <u>et al</u>., 1990). Ammonia release is small when litter pH is below 7.0, but substantial when litter pH is above 8.0. Uric acid decomposition is most favored in alkaline pH conditions. Uricase, the enzyme that catalyzes uric acid breakdown, has maximum activity at a pH of 9 with uric acid disappearance decreasing nearly linearly for more acid or alkaline pH values. One principal ureolytic bacterium, <u>Bacillus pasteurii</u>, can not grow at neutral pH, but thrives in litter above 8.5.

Several chemicals have been used to control or reduce ammonia release from poultry litter. They act by either inhibiting microbial growth, and hence uric acid decomposition, or by neutralizing ammonia by combining with the released ammonia

(Carlile, 1984) Phosphoric acid liquid treatment of poultry litter lowered litter pH and decreased ammonia levels compared to control, but caused concerns with phosphorus run-off (Reece et al., 1980). Sodium bisulfate is a dry acid used in poultry litter to control ammonia and lower litter pH to provide an environment in which bacteria can not grow. The objectives of this study were to determine the ammonia controlling ability and litter acidification properties of sodium bisulfate.

Two hundred 40' x 500' poultry houses were used for this trial in the mid-Atlantic region during the winter of 1996, one hundred had the litter treated with sodium bisulfate at rate of 2.5 kg/10m^2 by topdressing the litter the day before chick placement. The farms were paired and conditions in the matched control and treated houses were the same. Ammonia levels were measured with a hand-held pump with detection tubes at floor level before SBS treatment, immediately after treatment, and on a weekly basis for the flock duration. Litter pH levels were determined by collecting 60 ml of litter and mixing with an equal amount of distilled water and emerging an electronic digital pH meter into the slurry. All samples were collected in six different locations in the house and the data represents averages of those readings.

Ammonia Levels in ppm as Affected by SBS
SBS Treated Litter in 100 Houses vs. 100 Untreated Control Houses
Data represents Averages of 100 Houses in each group

	Before	After	1 Wk	2 Wks	3 Wks	4 Wks	5 Wks	6 Wks	7 Wks
SBS Treated	127	0	0	5	8	15	19	20	18
Control	119	119	125	125	138	114	128	98	97

Litter pH as Affected by SBS Treated Litter

	Before	After	1 Wk	2 Wks	3 Wks	4 Wks	5 Wks	6 Wks	7 Wks
SBS Treated	8.5	1.7	2.1	3.4	4.5	5.0	5.5	5.9	6.4
Control	8.9	8.9	8.7	9.1	8.5	9.3	8.6	8.1	8.9

In this study, SBS treated litter houses had significantly lower ammonia and litter pH than untreated litter control houses. Fuel usage was measured daily during the test period and the control houses averaged 43% greater usage than treated houses due to longer fan times and venting of heat.

The detrimental effects of ammonia in poultry production have been known for years. Numerous laboratory and field studies have shown how ammonia affects bird health and performance. High ammonia levels damage the bird's respiratory system and allow viruses and bacteria to cause infection leading to declining flock health and performance (Nagaraja et al., 1983). E. coli bacteria are significantly increased in the lungs, air sacs, and livers of birds exposed to ammonia following aerosol exposure to E. coli. Because of ammonia damaged tracheal cilia, clearance rate of E. coli from the bird is decreased compared to birds not exposed to ammonia (Nagaraja et al., 1984). Body weight, feed conversion, and condemnation rates of ammonia exposed birds are poorer as ammonia levels rise (Quarles and Caveny, 1979), and resistance to respiratory diseases is decreased (Anderson et al., 1964).

Bird Performance

Birds from the above study were processed and bird performance was evaluated between the SBS litter treated houses and the control non-treated litter houses.

Bird Performance as Affected by SBS Treated Litter

	# Birds	% Mortality	Age-Days	Avg. Weight (lbs.)	Avg. Daily Gain (lbs.)	Air sac Involvement
SBS Treated	1,282,256	7.14	51.7	5.39	.1043	1.80
Control	1,219,918	8.05	48.3	5.19	.1033	3.39

Litter Pathogens

The pH of poultry house litter has an affect on litter bacteria populations. As the litter pH decreases from an average litter pH of 8.0-9.0 down to 3.0, the bacteria load decreases (Hardin et al., 1989). This study was conducted in the laboratory in 2 polyethylene containers, 12" x 12" x 12" with sterilized poultry litter (wood-shavings) and in 12, 11' x 12' colony houses. the litter was treated with SBS at a rate of 3 lbs./100 sq. ft. by topdressing once. The litter was dragged over the surface with a 2" x 2" swab before and after SBS application and at 3, 6, 24, 48, 72, and 168 hours after SBS application. The litter was seeded with 1 x 10^9 colony forming units of Salmonella enteritidis strain 575 prior to SBS treatment. The litter drag swabs were cultured on MacConkey and XLD agar. All potential colonies were verified by biochemical assays and typed by anti-serum agglutination. Verified Salmonella colonies were quantified as no growth, 1-10, and >10 colonies. the pH of the litter was determined with an electronic digital pH meter.

In these trials, SBS treated litter had significantly lower pH than control, non-treated litter. This litter acidification in the SBS treated litter resulted in significantly lower Salmonella counts. These findings have implications for bird health and performance and food safety. Mallinson et al. (1992) have shown that litter Salmonella has been linked to poor bird feed conversion, and increased condemnations with

The Effect of SBS Treated Litter on *Salmonella enteritidis* (SE) Growth
Laboratory Trial

Hours After SBS Treatment	SBS Litter SE Colony Count	SBS Treated Litter pH	Control Litter SE Colony Count	Control Litter pH
0	++[a]	8.0	++	7.9
3	NG[b]	2.1	++	7.8
6	NG	2.3	++	7.5
24	NG	2.4	++	7.9
48	NG	2.3	++	8.1
72	NG	2.5	+	7.8
168	NG	2.8	+	7.9

[a] + = 1 - 10 colonies, ++ = > 10 colonies
[b] NG= No Growth

The Effect of SBS Treated Litter on *Salmonella enteritidis* (SE) Growth
Colony House Trial

Hours After SBS Treatment	SBS Litter SE Colony Count	SBS Treated Litter pH	Control Litter SE Colony Count	Control Litter pH
0	++[a]	8.0	++	8.3
3	NG[b]	3.8	++	8.3
6	NG	3.1	+	8.3
24	NG	2.8	++	8.4
48	NG	2.9	++	9.3
72	NG	3.5	+	8.4
168	NG	3.1	++	7.9

[a] + = 1 - 10 colonies, ++ = > 10 colonies
[b] NG= No Growth

decreased weight gains. They have linked on-farm HACCP program success with reduction of Salmonella and other pathogens and manipulation of litter characteristics as part of these programs.

Litter Beetles

The darkling beetle, Alphitobius diaperinus, also referred to as the lesser mealworm, litter beetle, black bug, and black poultry bug, is found abundantly in poultry house litter and manure worldwide. They originated in Africa, but have become well adapted pests in poultry houses feeding on dead birds, poultry feed, and manure. Untreated poultry litter is a perfect environment for beetle reproduction (Jones et al., 1994).

Beetles threaten profitable poultry production in three ways: 1) they burrow into and damage poultry house insulation, destroying up to 30% of the total insulation resulting in substantially higher fuel usage; 2) consumption of beetles and larvae by birds may result in decreased weight gain and feed efficiency; 3) beetles are well know transmitters of many costly poultry diseases (De Los Casas et al., 1972; Despins et al., 1974; Eidson et al., 1966).

The purpose of this trial was to determine the effect of litter acidification with SBS on beetle populations in poultry houses and the effect of litter acidification on effective life of insecticides. Twelve commercial broiler houses were used for this study. SBS was applied at 2.5 kg/10 sq. m in two houses, two houses had litter untreated as controls, and two houses each had litter treated with an organophosphate insecticide, pyrethroid insecticide, SBS with organophosphate, and SBS with pyrethroid. Beetle counts were done at several locations in each house on a weekly basis for the flock duration of seven weeks by using 1.5 inch diameter plastic tubes with corrugated cardboard inserts. The results showed that litter acidification is critical to insecticide efficacy with lower litter pH resulting in greatly increased life compared to higher, commonly found, litter pH and SBS helps lower beetle populations.

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THE EFFECT OF COMPOST MATERIALS AND METHODS ON HOUSE FLY PROPAGATION

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Note: This study is ongoing and final results have not yet been determined.

The current trend in farm demographics reflects a decrease in the number of small farms and an increase in the size of existing farms. This change often includes an increase in the number of animals without a corresponding increase in acreage, resulting in more animal units per acre. In addition, the increasing agricultural-urban interface has resulted in farm nuisances now affecting a greater number of residential dwellings. Two of the biggest nuisances associated with agricultural manure are foul odors and house fly propagation. Manure is the principal food of many insects, especially larval files." (Sheppard et al., 1994). Many species of flies breed and live in manure. The common house fly (Musca domestica L.), however, has the unique ability to travel distance, 3.7 miles in large numbers and up to 20 miles singly (Collison, 1986), and thus, affect neighboring communities.

It is accepted that composted manure handles easier with approximately a 50% volume reduction, has a dry peat like consistency, and lacks foul odor or fly problems associated with unprocessed manure (Rynk, 1992; LaCross and Graves, 1992). However, there is an absence of basic research associated with the composting process and fly life cycles. The only suggestion in composting literature given to control flies concerns breaking the fly's life cycle. For the purpose of fly control, composting literature suggests turning compost piles at least once a week to break the life cycle during fly season (Rynk, 1992). Crow (1980) suggests that the most effective management is to turn the piles every other day. Yet, turning compost piles every other day can become a very time consuming and costly process for the sole purpose of keeping your neighbors' houses fly free.

In Pennsylvania, seventy percent of farmers who compost use the turned windrow method of composting (Abel and Oshins, 1995). Graves et al. (1996, unpublished) compared different composting methods from the standpoint of cost efficiency. these methods include turned windrow systems using various turning methods and static systems including the Passive Aerated Windrow System (PAWS) and variations of PAWS. the purpose of this study was to determine a least cost method of composting. The PAWS method is rarely used on farms supposedly due to tighter restraints on the initial recipe (i.e. mixture must fall in a narrower moisture content range and must be more porous). Other disadvantages cited include uneven air distribution and material particle bulkiness not associated with turned systems (Rynk, 1989). Graves et al. (1996, unpublished) have found that the PAWS method utilizes less labor and equipment resulting in lower input costs than the turned systems. However, a PAWS pile is not turned and thus, fly populations are not controlled mechanically. The purpose of this study is to investigate how materials and methods used in composting systems effect house fly populations.

HYPOTHESIS

Fly propagation in composting systems is a function of the initial compost recipe (nutrients, odor, moisture content), composting methods (aerated windrow system, mechanical turned system, high or low maintenance), and environmental conditions (temperature, humidity, and light intensity). This study investigated the effects of selected materials used, moisture content of mix, and composting methods to determine effects on fly propagation.

METHODS

The house fly larva has a highly developed sensory structure enabling it to detect temperature, moisture, odors, and chemical constituents of food and habitat (Wilhoit et al., 1991). This study focused on how moisture content and material specific properties (which include chemical makeup and odor) affect fly population. In Phase I, three tests were conducted to study fly preference and medium ability to sustain growth with respect to selected materials, mixes or recipes, and moisture content (Figure 1). In Phase II, various composting systems were analyzed for their ability to sustain fly propagation.

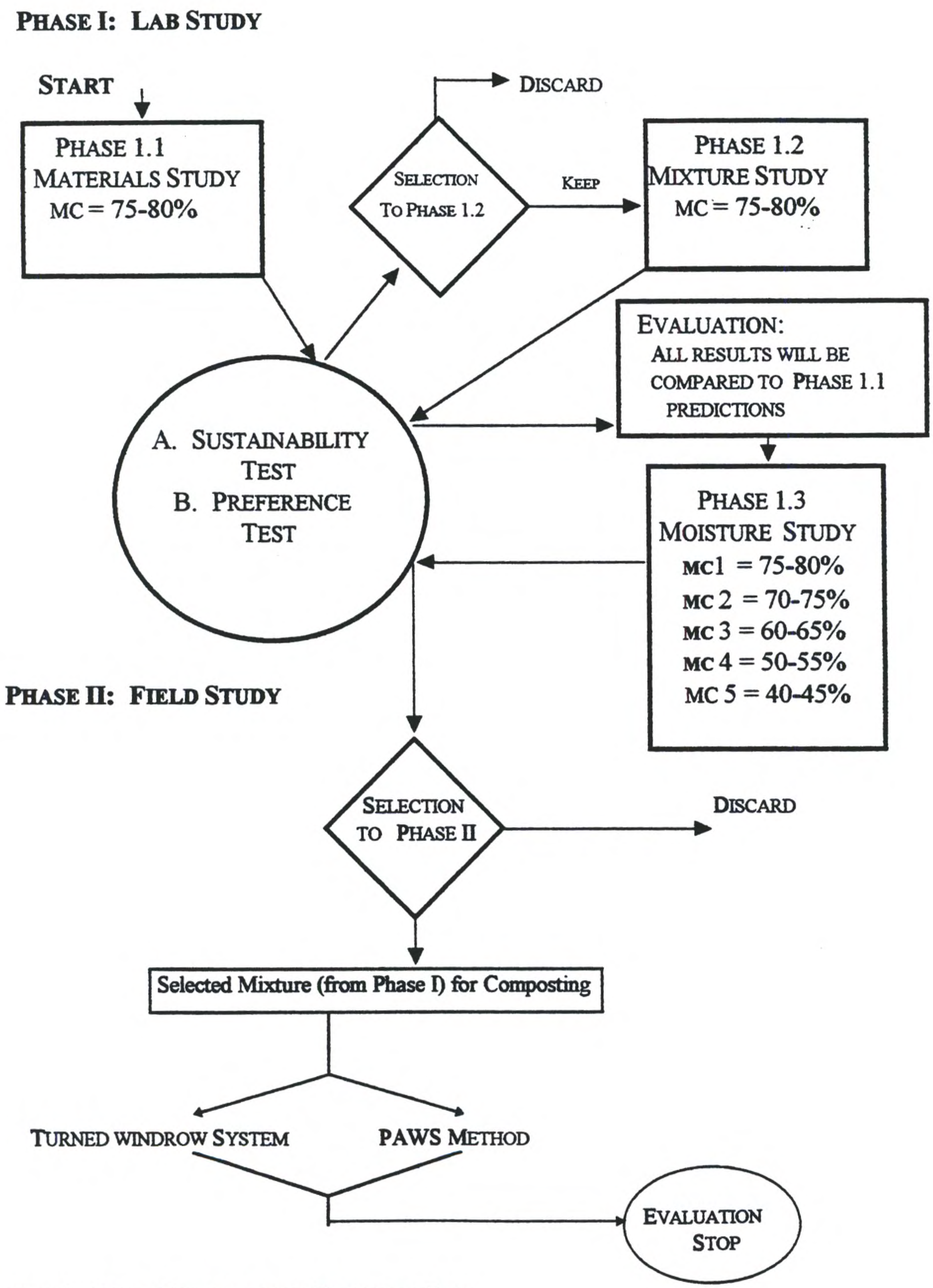

FIGURE 1. QUICK REFERENCE OF RESEARCH PLAN.

The first test of Phase I was a materials study to determine which materials flies prefer and in which they are able to develop to adult maturity. Materials included two manures, dairy and poultry, and seven amendments, oat straw, rye straw, moldy alfalfa hay, sawdust, newspaper, and mixed grass. Moisture content for all materials was within the 75 to 85% range.

The second test was a mixture test which studied combinations of selected amendments with both dairy and poultry manure to determine the best mix ratio or compost recipe to control flies. Mixtures consisted of a range of 100% manure to 80% amendment : 20% manure (Figure 2). The moisture content of all mixes were adjusted to the 75 to 85% range. Results were compared to those predicted by ratio from the mixture test.

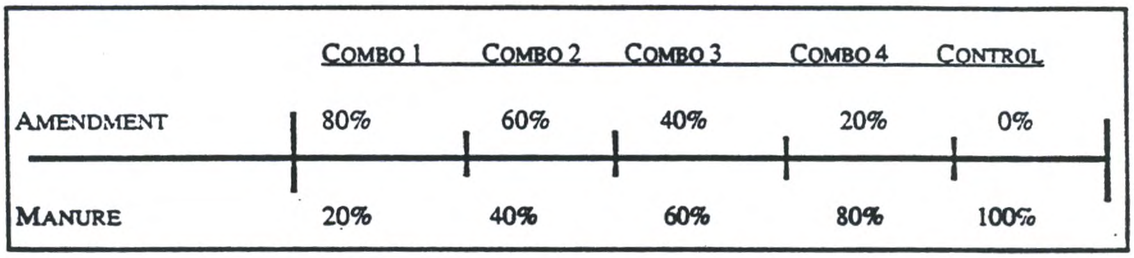

Figure 2. Diagram showing combinations of mixtures to be studied. All percentages are by weight.

The third test was to determine how moisture content affected fly populations. Both manures (poultry and dairy) were tested at five specified moisture contents. Desired moisture contents were obtained by adding a determined amount of one chosen amendment to each manure.

Each of the three tests (materials, mixture, and moisture) consisted of two parts. The first test was fly preference and the second was sustainability (ability to sustain larval development). A preference test determined which materials flies preferred by where eggs were laid. In the sustainability test, materials were tested for ability to support larval development. A specific number of eggs were planted in one hundred grams of medium and emergence is counted. Just as the temperature factor was studied by other researchers (Lysyk, 1991; Wilhoit et al., 1991; Lysyk and Axtell, 1987) to determine its relationship to fly development, moisture content, and raw material relationships were developed.

EXPERIMENTAL RESULTS

When 500 four day old flies were subjected to both manures along with the seven amendments, the highest preference was alfalfa (mean = 417.5, SD = 53.1) followed by rye straw (mean = 284.6, SD = 69.1), dairy manure (mean = 119.8, SD = 98.4), and finally, a small attraction to oat straw (mean = 16.5, SD = 19.2) (Figure 3). Interestingly, flies preferred dairy manure over chicken manure. In an independent study, only dairy and chicken manures were subjected to fly preference. Dairy manure consistently contained all the eggs laid during the 24 hour exposure period.

Immature larvae sustained development in their materials of preference: alfalfa, rye straw, dairy manure, and oat straw; as well as corn fodder and chicken manure. Zero emergence dominated the low nutrient value materials: sawdust and newspaper.

PRELIMINARY CONCLUSIONS

When composting to control fly populations, use amendments that have low nutrient value such as newspaper or sawdust. do not use high nutrient value materials such as moldy alfalfa.

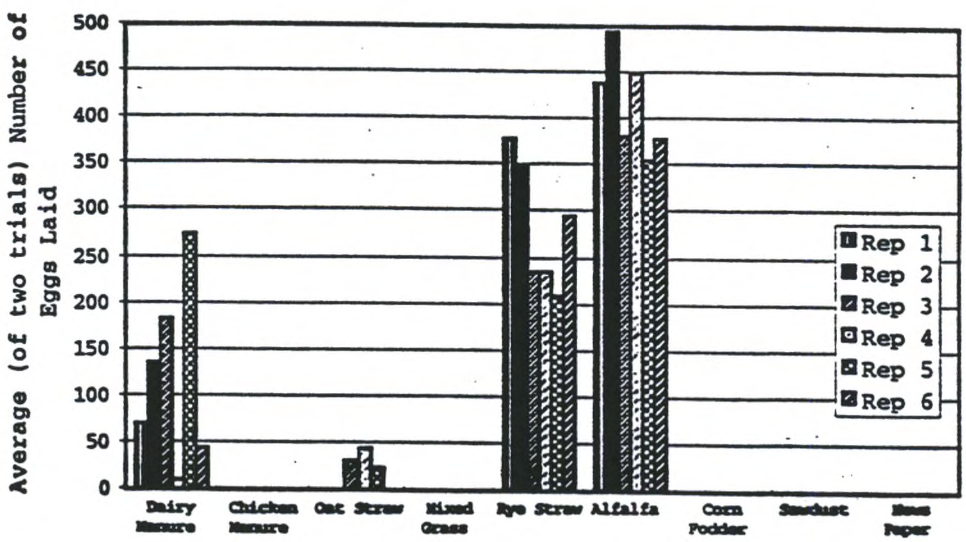

Figure 3. Fly preference of selected materials

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ECONOMIC ANALYSIS OF COMPOSTING SYSTEMS USED IN PENNSYLVANIA

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While odors associated with agricultural operations have always been with us and generally accepted by the rural population, the increasing agricultural-urban interface has resulted in increased farm nuisance complaints. Many of these complaints are centered on odors from animal agriculture and the handling of animal manures. In addition to odors, flies found in close proximity to animal operations have also generated complaints from our new urban neighbors. One manure management technique is to compost the manure before spreading on the field. Composting generally allows the farmer to control odors and flies substantially and reduces the volume to be transported and spread. But how much does it cost to keep one's neighbors happy and thus, oneself in business? This paper attempts to answer this question.

Composting methods can be classified into two general categories: the turned windrow system and the static or Passive Aerated Windrow System (PAWS). The turned windrow system uses regular mixing or agitation of the windrow as the main aeration affect. This increases porosity of the windrow and enhances the passive aeration to the pile. It can be accomplished by a bucket loader, a bucket loader in combination with a manure spreader and tractor, or with specialized compost turners. In the passive composting system there is little management or manipulation of the materials after they are mixed and piled. Turning occurs infrequently or not at all. The PAWS system is a passive system which uses a base of perforated pipe for aeration of the pile (Rynk, ed. 1992.)

The selection of composting method and reasons for composting agricultural manures and waste are wide ranging. The 1995 draft of the Pennsylvania On-Farm Composting Directory identifies 60 farmers that are currently composting with 38% marketing their product and 35% working with local municipalities by taking leaves and grass clippings. Seventy percent of these farmers use the turned windrow method of composting (Abel and Oshins, 1995). The PAWS method is rarely used on farms supposedly due to tighter restrains on the initial control of moisture content and particle size. Another disadvantage cited was uneven air distribution that is not associated with turned systems (Rynk, 1989). However, if a farmer is utilizing compost for the purpose of nuisance control, how often does the compost need to be turned? Does it need to be turned at all? What type of equipment investments are needed?

Fiorina et al. (1996) in four on-farm case studies, compared costs of three different manure management systems. The systems included comparison of direct costs of handling raw manure, liquid manure, and compost in a manure management system (see Table 1).

TABLE 1. Total costs of each system for four manure management case studies not including revenues and fertilizer benefits

	Farm A	Farm B	Farm C	Farm D
Raw Manure	$8,549	$5,044	$5,260	$11,631
Liquid	$18,199	$7,283	$2,646	$14,854
Compost	$12,764	$11,137	$8,316	$14,516
Per Wet Ton				
Raw Manure*	$2.78	$10.32	$71.56	$16.38
Liquid*	$5.92	$14.90	$36.00	$20.92
Compost*	$4.15	$22.78	$113.14	$20.44
Compost**	$11.00	$38.00	$113.00	$55.00

*Costs per wet ton manure.
**Costs per wet ton compost production.
Compiled table taken from Fiorina et al. (1996).

The cost of composting (wet ton compost produced) was always the highest cost practice. However, of all four case studies, the compost management practices and equipment of each of the farms included the use of a compost turner. That is, all four farms used the turned windrow system.

HYPOTHESIS

For the purpose of nuisance control, particularly odors, a passive aerated system of composting is effective and less costly than a turned system because there are no regular turnings needed. This appears to be advantageous for two reasons, specialized equipment does not have to be purchased, the time involved in weekly turnings is avoided.

METHODS

For any operation, including a composting operation, the economics of the system can be evaluated using three basic criteria: time, money, and space. During Fall 1995 data was collected to determine the costs of different styles of composting, utilizing the Penn State University's Composting Facilities. The experimental methods tested included four treatments, two static piles and two turned piles. the static piles had differing bases, one with a pipe base and the second with corn fodder base. Of the turned piles, one windrow was turned with a bucket loader in combination with a manure spreader and tractor while the second windrow was turned with only a bucket loader. All pines built used the same mix, approximately 18.5:1 of dairy manure to soybean straw mix. the static piles were built in mid-September while the turned piles were built in mid-October. Pile lengths ranged from 37 ft. to 57 ft. long and volumes varied from 1,240 -2,020 ft^3.

EXPERIMENTAL RESULTS

Temperature was approximately 20 degrees Fahreheit higher in the static piles than the turned piles (Figure 1). At the first this was accredited to the fact that the turned piles were built one month later in the rainy part of the year. It was hard to keep these windrows in the compostable moisture content range. Occasionally to dry out the windrows, dry material was added during when turning. However, during this summer (1996), three of the four treatments were built again. They include the turned pile using a bucket loader in

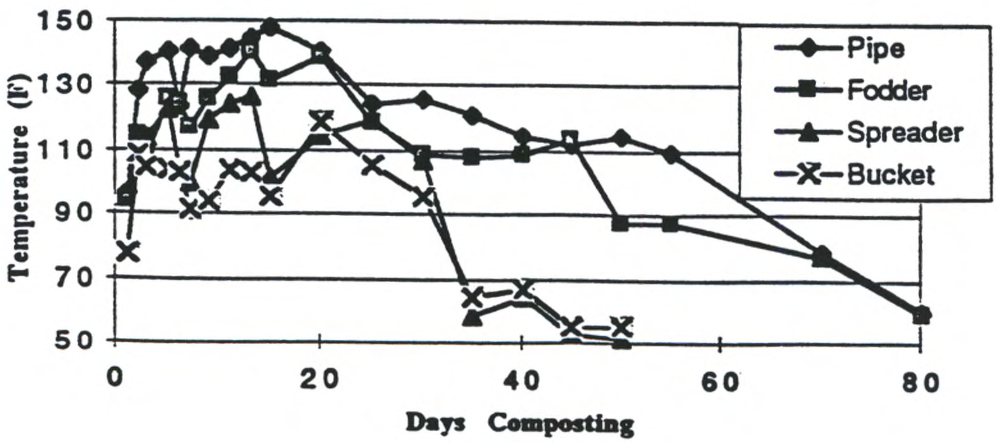

Figure 1. Temperature profile of the four types of compost windrows for Fall 1995

combination with a manure spreader and tractor, a static pile with fodder base, and a static pile with a pipe base. Although data collection on this system is not yet complete, the first ten days average temperatures indicate that the turned windrow is at least 30 F lower than the static windrows. The ten day average high temperature for the turned pile was 115.8 F, fodder base was 144.5 F, and pipe base was 160.3 F.

Cost of each system was calculated and is tabulated in Table 2. Cost sheets that were used to calculate the compiled costs are located in the appendix. Making compost using a static pile with pipe base costs approximately one half that of making compost with the turned method using the manure spreader. However, the compost that was made with the spreader was much finer in texture than that of the static systems or the turned using a bucket loader. During load out of the compost in the spring, the static piles were low in odor. To test for maturity, alfalfa seed was planted in the medium. All replications of the static piles germinated fully indicating a stable material.

TABLE 2. Compiled costs of each system. Unit cost determined assuming 2.5 cubic yard of compost equals one ton as specified by the composting council

Window Type	Volume ft^3	Building Cost ($)	Turning Cost ($)	Total Costs ($)	Unit Cost $/ton
Fodder Base	1240	221.73	0.00	221.73	12.07
Pipe Base	1740	202.86	0.00	202.86	7.87
Spreader	1420	158.56	171.21	329.77	15.68
Bucket Only	2020	214.64	110.30	324.94	10.86

CONCLUSIONS

From the standpoint of marketing the compost, the finer product is more appealing to the buyer. However, if one's goal is to spread the compost on the field, the static system using pipe base is most economical. It is suggest that before a farmer or potential composter makes decisions on our data, that he/she review the sheets and input their costs of raw materials and machinery. Our numbers are source documented but even these costs vary from farmer to farmer, and region to region.

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Building Costs for Static Piles

Fodder Pile–Building Costs							
Materials							
	Quantity	Unit Price	Mat'l Cost*				
Corn Fodder Base (LB)	1,540	$0.02	$36.19				
Soy Bean Straw (LB)	1,640	$0.04	$57.40				
Dairy Manure (LB)	58,690	$0.00	$0.00				
Materials Total:			**$93.59**				
Equipment and Labor							
	Time [hrs]	Unit Price	Eqpt Cost	Fuel [gal]**	Unit Price	Fuel Cost	
JD 4250 & Bale Processor	0.75	$40.82	$30.62	1.1	$0.96	$1.05	
NH 8340 & Manure Spreader	1	$40.82	$40.82	2.6	$0.96	$2.49	
Case 580 Loader (0.7 yd^3 bucket)	2.16	$23.01	$49.70	3.6	$0.96	$3.45	
Equipment & Labor Total:	**3.91**		**$121.14**	**7.3**		**$7.00**	
Grand Total to Build 1,240 ft^3 pile:	**$221.73**						
Cost / ft^3:	**$0.18**						

Pipe Pile – Building Costs							
Materials	Quantity	Unit Price	Mat'l Cost*				
10'x4" Schedule 40 (DWC/cell) PVC Pipe (~0.5" walls)	15	$11.47	$28.68	–>assume 6 uses; no salvage value			
10'x4" Sewer and Drain Perforated (~0.25" walls)	15	$4.24	$31.80	–> assume 2 uses; no salvage value			
Soybean Straw (LB)	2060	$0.04	$72.10				
Dairy Manure (LB)	74090	$0.00	$0.00				
Materials Total:			**$132.58**				
Equipment & Labor	Time [hrs]	Unit Price	Eqpt Cost	Fuel [gal]**	Unit Price	Fuel Cost	
NH 8340 & Manure Spreader	0.42	$40.82	$17.14	0.85	$0.96	$0.82	
Case 580 Loader (0.7 yd^3 bucket)	1.67	$23.01	$38.43	2.1	$0.96	$2.01	
Time to drill holes in Schedule 40 pipe (assume 6 uses)	2.5	$8.50	$3.54				
Time to lay Pipe	0.5	$16.68	$8.34				
Equipment & Labor Total:	**5.09**		**$67.45**	**2.95**		**$2.83**	
Grand Total to Build 1,740 ft^3 pile:	**$202.86**						
Cost / ft^3:	**$0.12**						
* Materials cost do not include hauling to site.							
** Fuel consumption calculated.							
Note: All costs are composting related; does not include travel to site costs, or downtime.							

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