Virginia Cooperative Extension

PUBLICATION 442-309

Manure Management and Environmental Stewardship

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Introduction

Manure is one resource that – if not managed properly – will affect the quality of the environment. Thus, livestock and poultry producers, regardless of size, need to manage manure for better economic returns and environmental protection. Quite often, we read or hear from news media about conflicts arising from the nuisance of odors from livestock and poultry operations, fish kills in water bodies, or the pollution potential of surface or groundwater that results from poor manure management. These concerns have created strained relationships between animal agriculture and the general public. To avoid or repair these relationships, it is important that we manage manure and other agricultural wastes associated with animal production in a responsible manner.

Environmental Stewardship

According to the U.S. Environmental Protection Agency, environmental stewardship is the responsibility for environmental quality shared by all those whose actions affect the environment.

Good manure management starts with recognizing and understanding the value of manure as a resource that contains nutrients for crop production as well as the potential negative impacts manure can have on air, water, and soil. This publication outlines the general guidelines about managing livestock and poultry manure and provides a list of resources with detailed information on specific topics of good practices for manure management and use.

Benefits of Manure

Manure is commonly used as a fertilizer and as an amendment to improve the quality of the soil. When manure is applied and managed properly according to the agronomic needs of crops, manure will improve crop productivity and reduce the demand for commercial fertilizer (see *Phosphorus, Agriculture & the Environment*, Virginia Cooperative Extension [VCE] publication 424-029; and *Impact of Changing From Nitrogen- to Phosphorus-Based Manure Nutrient Management Plans*, VCE publication 442-310). Managing manure to provide balanced nutrients that can be used as fertilizer may require that some nutrients be removed, conserved, or concentrated. For example, if the nitrogen (N) to phosphorus (P) ratio in the manure is one-to-one (1:1) and the agronomic requirement for these nutrients by a crop is four-to-one (4:1), meeting the agronomic needs of the crop using manure may require that some phosphorus be removed. Also, knowing that nitrogen can be lost from manure through volatilization of ammonia, it may be necessary to use management practices that will conserve nitrogen in the manure. If manure must be transported for long distances, it may be important to concentrate the nutrients to reduce the volume of water that has to be transported with manure in order to reduce transportation costs.

Nutrients can be recovered, conserved, or concentrated in manure through one or a combination of physical, chemical, or biological methods (see *Selecting a Treatment Technology for Manure Management*, VCE publication 442-306). Crops usually need more nitrogen than phosphorus; therefore, it would be beneficial to concentrate the nitrogen and remove the excess phosphorus from the manure to get the full benefits of manure using nutrient-recovery technologies that involve chemical, biological – or a combination of both – methods and a manure-separation system.

If handled properly, manure can be used to produce biogas that can be used as an alternative energy source (see

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Produced by Communications and Marketing, College of Agriculture and Life Sciences, Virginia Polytechnic Institute and State University, 2010

Biomethane Technology, VCE publication 442-881). The biogas can then be used to produce electricity, hot water, steam, and/or transportation fuels. The quantity and quality of gas produced will depend on the digester design, operating temperature, and the type and quality of manure fed to the digester. Animal manure can also be subjected to the process of pyrolysis to produce char, oils, and gas. The oils and chars can be used for fuel or further processed to produce value-added products, such as plastics. Other considerations are to burn dried or solid manure in combustors or gasifiers to produce heat.

Another use for animal manure is as culture for yeast and algae production, which can then be used to produce animal and fish feed and biofuel (see *Microalgae as a Feedstock for Biofuel Production*, VCE publication 442-886). Manures can also be used in the production of mushrooms or composted to produce a weed- and pathogen-free, high-quality soil amendment.

Manure Management and Water Quality

Water quality is everyone's concern and it is important to remember that poor nutrient management can lead to water quality problems. The EPA reports that manure from animal agriculture is one of the major sources of contamination of our water supply. Manure contains nitrogen, phosphorus, organic matter, and pathogens that are considered four primary contaminants that affect water quality. These pollutants may enter water resources by runoff, leaching, and deposition from the atmosphere. Nutrients from the atmosphere may be deposited on land through precipitation (rain and snow fall) or dry deposition. These contaminants may increase the cost of treating the water for domestic and industrial uses.

How Manure Constituents Affect Water Quality

Nitrogen

Nitrogen is one of the basic components of proteins, which is a part of all living things. Nitrogen is usually provided to animals via feed. Animals use only part of the nitrogen in their feed to produce meat, milk, or eggs and for body growth and maintenance. The remaining protein is excreted.

Nitrogen in manure exists in two forms that can be described as inorganic or organic. The inorganic forms include ammonia, nitrate, and nitrite. The organic forms include urea, undigested proteins in manure and feed, and other animal waste products such as hair and feathers. The inorganic forms readily cause pollution when compared to the organic forms. However, when the organic forms of nitrogen decompose, ammonia is produced. Ammonia can be transformed into nitrates and nitrites when oxygen is provided to the manure. Ammonia can easily be lost to the atmosphere from the manure by volatilization. Different forms of nitrogen present different risks to water quality. Ammonia concentration exceeding 2 parts per million (ppm) can lead to fish kills. Nitrates above 10 ppm in drinking water may cause blue baby syndrome when consumed by infants. Excess nitrogen can cause eutrophication of surface-water resources.

Phosphorus

Phosphorus is an essential nutrient to plant growth and development. Animals require it for bone development and optimum production. Animal manure that is land-applied to supply nutrients for crop growth typically does not match the nitrogen-to-phosphorus (N:P) ratio required by crops. Consequently, if manure is applied to satisfy the nitrogen requirements of a crop, phosphorus is over-applied and the soil phosphorus levels can increase (see *Soil Test Note No. 5: Fertilizing with Manures*, VCE publication 452-705; and *Phosphorus, Agriculture & the Environment*, VCE publication 424-029). When soils become saturated with phosphorus, the potential for losing it in runoff water increases. Phosphorus typically moves with water runoff and soil erosion. It can be attached to minerals containing iron, aluminum, and calcium or to organic matter such as crop residue, bacteria in the soil or manure, or decaying organic matter.

Pathogens

Pathogens include microorganisms such as viruses, bacteria, and protozoa that cause infection or disease. Disease-causing microorganisms may be present in manure. Therefore, it is important to maintain adequate separation between the potential source of pollutants and water sources. Pathogens are most likely transported to water with surface runoff and erosion or by direct animal access to surface water. Streams and lakes used for drinking water and recreational purposes provide the greatest opportunities for transmitting these pathogens. Human beings may be infected if they consume crops irrigated with untreated manure that contains pathogens.

Organic Matter

Organic matter in manure can be a valuable environmental resource if managed properly; however, if manure reaches a water body or moves off-site by water runoff, organic matter can become a harmful pollutant. Organic matter can come from manure, silage leachate, and milking center wastewater. Organic matter degrades rapidly in water and may result in oxygen depletion in bodies of water. Organic matter is transported into water by surface runoff. Rarely does organic matter leach through the soil.

Manure Management and Air Quality

Manure handling, storage, and utilization in livestock and poultry production results in a wide range of air emissions, which may create air quality concerns. The airborne emissions from livestock and animal production systems include hazardous gases, (e.g., ammonia [NH_3] and hydrogen sulfide [H_2S]), odor, dust, and greenhouse gases (e.g., methane [CH_4], nitrous oxide [N_2O] and carbon dioxide [CO_2]). Dust is generated from regular farm traffic, land preparation, and other crop production activities, as well as from livestock and poultry barns with ventilation exhaust air. The concerns from these emissions include odor, atmospheric visibility, and respiratory health issues (see *Ammonia Emissions and Animal Agriculture*, VCE publication 442-110).

Relationships and Manure Management

Complex technologies or treatment systems are not the solution to good manure management. Sometimes the often forgotten or ignored relationship with your neighbor can resolve many issues arising from animal agriculture, especially with respect to odor.

Impacts of Air Emissions

Odorous compounds are commonly considered to be unpleasant or nuisance experiences by neighbors. Neighbors sometimes relate or determine odor nuisance by a number of factors, including frequency and duration of occurrence; intensity of the odor experience; social factors, such as past experience with agriculture and relationship with the producer; and appearance of the production facility. Some neighbors may have strong emotional reactions and possible health-related issues to livestock- and poultry animal-related odor. Their concerns should be taken seriously. Ammonia released into the atmosphere is a loss of fertilizer value of the manure nitrogen. It may also result in formation of particulate matter that contributes to haze in the atmosphere. If the particulate matter is deposited back on land or on surface water, it may lead to area nitrogen enrichment and cause pollution. Livestock production is a source of greenhouse gases, and greenhouse gases contribute to global warming.

Principles of Environmental Stewardship

According to the EPA, "Environmental stewardship is the responsibility for environmental quality shared by all those whose actions affect the environment." Some good manure management and environmental stewardship principles that may be of benefit to livestock and poultry producers are summarized below.

Awareness of Environmental Risks

Familiarize yourself with your operation's potential environmental impacts by conducting an evaluation to determine the highest-risk situations or practices on your farm. Develop plans and invest resource to address the high-risk situations, e.g., handling manure emergency spills and manure storage failures. Your local Extension office, the soil and water conservation district office, and the National Resources Conservation Service may provide you with information on how to perform this task.

Farm Nutrient Balance and Nutrient Management Plan

Animal producers should set a goal to balance nutrients on their farm and also manage soils in ways to minimize nutrient losses. Nutrient balance should consider what is coming into the farm as purchased feed and fertilizer and the nutrients leaving as managed products, such as crops, animals, or animal products. An example of nutrient flow in a farm is provided in figure 1.

If the nutrients coming into the farm are more than what leaves, this will result in an accumulation of those nutrients on the farm. To correct the nutrient concentration, consider a whole-farm approach rather than focusing on a small part of the production, such as nutrients in manure and their losses to the environment. Understand the big picture by identifying the underlying cause of nutrient concentration and develop effective solutions to address the critical areas for better

utilization and management of nutrients on your farm. Some strategies to reduce and manage manure nutrients are presented in *Strategies to Reduce Amounts of Nitrogen and Phosphorus in Dairy Rations*, VCE publication 404-130; and *Selecting a Technology to Manage Manure Nutrients*,VCE publication 442-326.

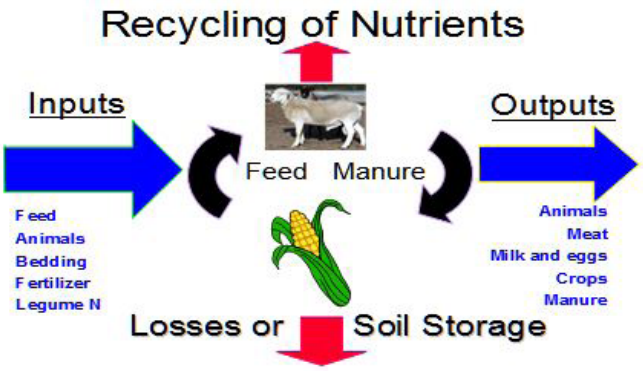

Figure 1. General nutrient balance on a farm.

Recycle nutrients between livestock and crop components within the boundaries of the farm. Manure nutrients are recycled as fertilizer for crop production. Crops are then cycled as feed to livestock or poultry. Nutrients leave the farm as products, i.e., animals or crops products such as milk and eggs and manure sold or given away for use outside the farm. These nutrients are sometimes referred to as "managed outputs." Some nutrients will leave the farm as environmental losses, e.g., nitrogen lost to the atmosphere as ammonia, nitrates to groundwater, and nitrogen and phosphorus in surface-water runoff.

Use manure according to a nutrient management plan. The nutrient management plan should maintain a balance between nutrient application and crop use and the needs of that nutrient. Test manure to know its nutrient content. Test soils to establish existing soil fertility levels to know what is needed for the different crops you grow (see *Soil Test Note No. 1: Explanation of Soil Tests,* VCE publication 452-701; *Soil Test Note No. 2: Field Crops,* VCE publication 452-702; *Soil Test Note No. 3: Forage Crops,* VCE publication 452-703; and *Soil Test Note No. 4: Trace Elements,* VCE publication 452-704).

Apply manure at uniform rates based on crop nutrient needs while avoiding soil contamination, crop damage, and runoff (see *Soil Test Note No. 5: Fertilizing with Manure*, VCE publication 452-705). Adjust the rate of supplemental fertilizer to compensate for the nutrients applied in the manure. Keep records of all your activities.

Use of manure and fertilizer as nutrient sources for crop production must be managed properly to ensure that they do not contaminate groundwater or surface water. Check soil moisture before applying manure and adjust application rates to avoid runoff. Limit the volume of water applied to an amount that brings the soil to field-moisture capacity. Do not apply manure to saturated soils. Incorporate raw or untreated manure to reduce odors and nitrogen losses. Calibrate application equipment to obtain the desired application rate (see *Land Application of Broiler and Turkey Litter for Farming Operations Without a DEQ Permit,* VCE publication 442-052; *Manure Spreader Calibration for Rear-Discharge Equipment: Handling Solid and Semisolid Manures and Poultry Litter,* VCE publication 442-004).

Be a Good Neighbor

Animal production creates several potential nuisances, including odors, flies, noise, and dust. You need to be fully aware of these nuisances and your neighbors' possible concerns. The demographics of rural areas (where farming has traditionally occurred) are changing and what used to be exclusively rural areas are becoming urbanized. Public awareness of environmental issues is changing. As a result, farm-neighbor conflicts are increasing around the country. Nonfarm communities complain that farming activities near their homes affect their quality of life. Increasingly, farmers are being forced to consider social as well as air-quality concerns in developing manure management plans. Following are some reminders of good practice as part of your manure management strategy:

Know Your Neighbors

We have numerous and diverse neighbors. Some are long-term residents who farmed in the area and are now retired. Some are the result of urban sprawl. Some live in communities within the city limits but next to agricultural land. Schools, churches, hospitals, and golf courses are also some of your neighbors. It is interesting to note that some nonfarm community members are buying former farms and moving into the country, seeking "fresh" air. The bottom line is that urbaniza-

tion of rural areas and consolidation of livestock farms often lead to tense relationships between farmers and nonfarming neighbors. It is important to recognize this fact and to proactively pursue ways to deal with it. How you handle business on your farm may impact how you resolve conflicts related to your farm.

Recognize Your Challenges

Large numbers of animals concentrated near nonagricultural residents will produce odor and visual issues related to confined-animal feeding operations. With the changing demographics, rural roads may start experiencing aggressive drivers who do not appreciate or recognize the slower farm traffic. With the hectic pace of life there may be little, if any, communication between the farmer and neighbors. This can create situations for misunderstanding and a greater likelihood that conflicts will occur. Sometimes common ground and mutual agreement is not realized until later. Do not let issues concerning your manure management get out of control. Be proactive in talking to your neighbors. Implement responsible farm management practices while conducting activities that promote the benefits of the farm to neighbors and the community.

Tell Your Story

There are a variety of outreach efforts you may want to consider to enhance the perception of the farm among neighbors and the larger community. Accept visitors to your farm as your schedule will allow and within the bounds of biosecurity. Tell visitors what you do and why you do it. Visitors should include all ages and groups. If possible, provide neighbors with sample farm products, assist with or volunteer to mow brush in the summer, plow snow in the winter, and consider allowing access to areas of the farm for recreational activities. Let your neighbors know about your farming operations and activities. This should include the manure application schedule. If neighbors have special events occurring at their homes on certain dates that may be impacted by a farming operation, such as land application of manure, work with them to reschedule that operation. Note: Outreach to community, open houses, and neighborly assistance can help cultivate open communication and understanding between the farming and nonfarming communities.

Engage Local Leadership

Before embarking on new projects or expanding existing enterprises on the farm, arrange to meet with the local authority boards to show them your plans and solicit questions and comments. After finishing the project, hold a neighborhood barbecue and tour to meet the neighbors; show them what you do and why. It is more difficult to carry a disagreement with someone you know and are friendly with or who has made a first move to get to know you.

Neighbor Relations

When planning farm operations that will impact people in the area (e.g., spraying liquid manure next to a school, church, or golf course), communicate and explain the operation ahead of time. Plan the operation at a time that causes the least disruptions to the other parties. Remember, people are much more accommodating if issues are addressed ahead of time, even if it is something they do not particularly like. In most cases, people will give you more latitude with something they do not like if you make a good faith effort to deal with their concerns about your farming operation.

Cleanliness

Many times people tend to smell with their eyes more than their noses. It is therefore extremely important to have a neat facility, clean animals, well-tended crops and buildings, and machinery in good repair. Yards

Figure 2. Examples of neatly kept farm surroundings.

Figure 3. Example of undesirable situations around the farm.

around barns and along the road and ditches should be mowed. It is not always possible to prevent all farm odors, but if people are presented with the picture of a clean, orderly, well-managed farm, they will tolerate more actual odor than from a farm that looks untidy (figures 2 and 3).

Safety and Manure Handling

Liquid manure can produce gases that can be toxic. Production of manure gases is enhanced in hot weather, so practice caution when handling manure in the summer. Remember that outdoor manure storages can be deathtraps (see *Manure Storage: Selection and Location of Poultry and Livestock Manure Storage,* VCE publication 442-307; and *Poultry and Livestock Manure Storage: Management and Safety*, VCE publication 442-308).

Acknowledgements

The author would like to express appreciation for the review and comments made by Lori Marsh, associate professor, food science and technology, Virginia Tech; Mike Roberts, Extension agent, Virginia Cooperative Extension Prince George County Office; Chase Scott, Extension agent, Virginia Cooperative Extension Wythe County Office; Jon Rausch, Extension program director, environmental management, The Ohio State University; and Robert Grisso, professor and Extension specialist, biological systems engineering, Virginia Tech.

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