Manure Nutrient Export Strategies

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Introduction

By December 2006, dairy producers will need to make operational changes to comply with requirements in the Federal Clean Water Act that changed after December, 2002. The changes at the Federal level can take a lot of time to trickle down to state regulatory agencies and then to dairy producers. In some states, producers already know their legal obligations, but producers in other states are unclear on what to do. The challenge is that ALL producers will need to IMPLEMENT their operational changes by December, 2006. The "crunch" time will be quite short for those producers who reside in states that are lagging in the regulatory process.

Four steps to identify your needs and determine your stress level

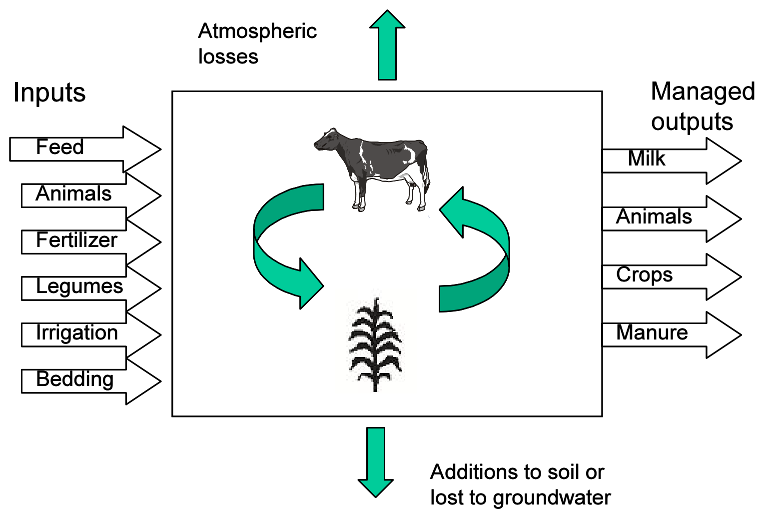
The first step is to assess your situation and identify the environmental parameters important to your dairy. What are the water quality concerns at your dairy? What are the water quality concerns in your watershed? Are you concerned about surface water? Do you have concerns about groundwater? Are air emissions and/or nuisance issues an environmental concern? Note that the two key elements of concern for water quality are phosphorus (P) and nitrogen (N), but salt accumulation can also be a concern.

The second step is to determine if you need to develop a nutrient export strategy (i.e., to determine if sufficient cropland is currently available at the facility). One way to do this is to compare the sum of nutrients excreted and fertilizer purchased to crop uptake. A ratio of 2:1 for N is a conservative goal to be protective of groundwater quality, and a ratio of 1.2 to 1.5:1 is a useful goal for P. Salt ratios have not yet been determined.

A better way is to conduct a whole farm nutrient balance. This is an analysis of the nutrient inputs (feed, animals, fertilizer, irrigation, bedding, legumes) and managed nutrient outputs (animals, crops, manure, milk). The whole farm balance is not an assessment of nutrient application practices.

Figure 1 shows typical nutrient inputs, outputs, and losses at a dairy. The difference between nutrient inputs and managed outputs are the losses that indicate a farm's nutrient-related water quality risk: the greater the difference (i.e., the greater the losses), the higher the risk.

Figure 1. Whole Farm Nutrient Balance.



Tools are available to assist you in calculating whole farm nutrient balance. Individuals in some states can use the tool developed by Rick Koelsch at the University of Nebraska (http://manure.unl.edu/koelsch-nbalance.html). In other states, there may be a more appropriate tool to use. You should contact your local dairy trade association representative, Cooperative Extension Agent or Advisor, USDA Natural Resources Conservation Service office or regulator to identify an appropriate tool to use to make your first whole farm assessment.

A whole farm balance can help determine if major or minor changes are needed in the facility's manure management program in order to protect the environment and to be able to operate in compliance with permit conditions. A farm may be considered "in balance" when the ratio of inputs to managed outputs is approximately 1:1 for P and 2:1 for N. The farm may be imbalanced when the ratio of inputs to managed outputs exceeds those ratios. In situations where there is a large imbalance between the nutrients produced at the facility and the nutrients exported or used at the facility, a producer may find that it is not economically feasible to make the needed improvements, and may decide to move some or all of their operations to another facility.

Producers who are not able to identify all records needed to calculate a whole farm balance may choose to use the Manure Production Characteristics Table D384.2 to estimate N and P excretion. The newly revised table should be available in 2005, and it will use dietary information and milk production records to estimate excretion.

The third step is to evaluate your nutrient application practices. Application of manure on land is not acceptable if the manure is applied without both soil and manure tests. The following brief list of questions developed in the Livestock and Poultry Environmental Stewardship Curriculum (http://www.lpes.org click on Interactive Assessment Tools) can help you determine your nutrient application practices (Table 1).

Table 1. Assessment to determine potential for nutrient imbalance[1].

Parameter to evaluate	Yes	No	Do not know
Soil P levels for the majority of fields are increasing with time.			
Soil P levels for the majority of fields are identified as "High" or "Very High" on the soil test.			
The majority (more than 50%) of the protein and P in the ration originates from off-farm sources.			
Livestock feed programs routinely contain higher levels of protein and/or P than National Research Council or land-grant university recommendations.			
A manure nutrient management plan is not currently used to determine appropriate manure application rates to crops.			
Less than 1 acre of crop land is available per animal (1,000 lbs of live weight), and no manure is transported to off-farm users.			
The ratio of P applied exceeds 1.3 times crop P uptake.			
The ratio of plant available N to total N applied to crops is less than 4:1 (including soils where solid manure is applied).			
Salt application exceeds crop salt uptake.			

[1] Adapted from Koelsch, R. "Whole Farm Nutrient Planning." Lesson 2 in Livestock and Poultry Environmental Stewardship Curriculum.

The fourth step is to conduct field-by-field balances of nutrients to determine if nutrients are applied appropriately. Facilities with sufficient land base for nutrient application must still be sure nutrients are applied appropriately. It is inappropriate for one or two fields to receive over application of manure.

Considering the variability at each dairy in both animal and crop management, there is no magical number of cows per acre of land. After the initial whole farm balance assessment and determination of the ability of land to utilize nutrients are accomplished, one can more clearly understand the potential needs to establish nutrient export strategies.

Nutrient export strategies

The ultimate goal of nutrient export strategies is to balance the farm for nutrients of concern. It is critical to keep in mind the goal before, during, and after identifying your strategies. How far out of balance is the farm? How much effort and how many resources will be needed to return the farm to balance (Figure 2)?

Figure 2. Shifting the imbalance of nutrient inputs to managed nutrient outputs.

At least ten potential opportunities should be evaluated to reduce your nutrient imbalance. The impact of each of these opportunities will vary depending on the original imbalance and local physical, structural, environmental, and economic pressures.

1. Modify diet. Dietary modification typically results in the greatest return on investment dollar to obtain nutrient reduction to reduce nutrient imbalances of N, P, and salt. However, a decrease in N excretion does not guarantee a decrease in system wide ammonia volatilization. Have a thorough evaluation of your nutritional program conducted. All elements fed in excess of cropland application needs should be evaluated. Most ration balancing programs are based on a least cost analysis with constraints of minimum amounts of nutrients. Restrictions for maximum amounts of nutrients are seldom included.

2. Alter cropping practices. Growing an additional or alternate crop can significantly improve nutrient balance. Additional cropping increases uptake of crop nutrients at the dairy and reduces the need to export manure nutrients. Cropping practices to improve yields or otherwise increase nutrient uptake (potentially changing cultivars or crop type) can also be helpful, but must be done judiciously to provide adequate forage base to the animals. In some parts of the United States, producers are finding that use of no-till techniques allows them to plant and harvest an additional crop each year or at least some years. This additional crop is beneficial for nutrient management.

3. Alter bedding strategies. Nutrients in the form of bedding used in freestall facilities become part of a slurry or liquid manure handling system; therefore, It may is logical to study bedding from a nutrient management point of view. When solid manure is used as the bedding source, nutrients are transferred from the solid manure storage area to liquid or slurry storage area. This decreases the ability of the operator to transfer the manure nutrients off site.

4. Implement a nutrient management plan. Plan to effectively use manure nutrients whenever possible and reduce the use of fertilizer (imported nutrients). Nutrient imports in the form of fertilizer should be minimized in order to allow the greatest use of manure nutrients in nutrient management plans. It is important to utilize manure nutrient testing, and soil and plant tissue testing to determine the need for fertilizer.

5. Improve accessibility to cropland. Ensuring that all cropland can receive manure reduces the need to import fertilizer. Some facilities have sufficient farmland to utilize nutrients in manure, but they lack the infrastructure to get the manure to the fields. Investment in roads, trucks, pipelines may benefit the ability to utilize nutrients at a facility and minimize nutrient imbalance.

6. Export crops. If sufficient changes are made as described in Item 2 above, there may be an opportunity to export crops. Sale of crops removes the nutrients from the facility and reduces imbalance.

7. Export manure nutrients to farmland. Find additional land nearby, either farmed by you or a neighbor, for land application. Increasing the amount of nutrients leaving the facility certainly improves the nutrient bottom line. However, some watersheds have a greater supply than demand for nutrients so this may not be possible. Finding additional land for manure nutrient application may require skill, marketing, and providing outstanding service. Potential services to provide include transportation, application, paperwork completion, nutrient analyses reporting, and nuisance avoidance. A brief list of potential services is provided (Table 2).

Table 2. Services to be offered in support of manure transfer to off-farm users[1]

A. Handling and application services to be included with manure	
• Loading of manure	• Transport of manure to site
• Land application of manure	• Incorporation of manure
B. Agronomic services to be included for assisting users in agronomic applications of manure	
• Calibration of manure applicator	• Consulting agronomist
• Soil testing	• Manure analysis
• Customer report following application of manure nutrient rates	
C. Nuisance avoidance services to be included with transfer of manure to off-farm user	
• Incorporation of manure	• Setback of application from homes
• Composting of manure	• Setback of application from waters of the state
• Notification of neighbors	• Other setbacks
• Notification of local government	• Timing to limit nuisance
D. Manure nutrient analyses tests	

[1] Information obtained from http://cnmp.unl.edu/MA%20Form13.pdf .

8. Densify nutrients for subsequent export. Individuals often jump to the concept of exporting nutrients in lieu of changing inputs or non-manure exports. Many producers find that a combination of dietary manipulation and treatment technologies may work effectively.

Excessive quantities of manure nutrients in watersheds have lead to development of manure handling consortiums. Economic viability of options typically requires substantial reorganization of manure handling systems (Goodwin, 2002). Marketability of the end product, required infrastructure to process and transport manure, and other logistics affect economic viability. Few lasting successes exist in the United States, although many areas have looked into communal manure management. A cooperative composting project is underway in Texas spear headed by the Texas State Soil and Water Conservation Board (http://www.tsswcb.state.tx.us/press/pr20020619.html). In other areas, feasibility studies have been conducted for anaerobic digestion projects (Bennett, 1999). Treatment technology companies have sought out larger dairy producers or areas where large numbers of milking cows are in close proximity to use manure as a fuel source. Most of the waste-to-energy technologies remain in the talking stages.

Keep your overall objectives in mind before you start. Clearly define the management objectives for use of specific manure treatment technology. Identify the data to collect and analyze to determine if the technology is functioning properly and adequately. What are the expectations of the technology? What are the consequences of using the technology? Are there additional ramifications that must be addressed? Most importantly, what is your alternative plan if your dairy permit relies on the function and productivity of a technology and it fails? One of the major considerations when evaluating technologies is "what is your real cost per unit of nutrient removed from your facility?". This must be addressed before you purchase the technology. Key areas to address prior to technology adoption are in Table 3.

Table 3. Parameters of concern prior to technology adoption.

Parameter	Initial cost	Annual maintenance
Technology		
Operation/resources		
Dedicated labor resources		
Knowledge/skills needed to operate technology		
	Income/value	Comments
Material reduction		
Nuisance reduction		
Nutrient removal		
Pathogen reduction		
Energy production		
Goodwill in community		
	Compliance documentation	Comments
Responsible person for regulatory compliance documentation		
Technology evaluation for consistency		
Lag-time before start-up		
Availability of technical assistance		
Reliability of technology		
Cost of sample analyses to document compliance		
	Other consequences of technology	
Unanticipated consequences		

Solid liquid separation is one of the first areas producers consider to identify manure for export. Traditional gravity separation screens provide relatively little removal of N, P or salts. These nutrients are soluble and remain in the liquid fraction. There are nutrients in the separated solids. We previously reported the efficiency of solids separation for standard mechanical separators and for a custom made, large surface area, weeping wall system (Meyer et al. 2003). Nutrient data from the weeping wall analyses showed no difference in the concentration of nutrients in the influent compared to the effluent of materials entering and exiting the weeping wall structure (Meyer, et al., 2004). Solids and nutrients were removed from liquid manure, however this was a small amount of the nutrients that were introduced into the liquid system. It is important for each facility to sample and quantify nutrient content and pounds of nutrients removed if solids are removed from the facility.

Consider use of scraping or vacuuming to collect freestall manure/bedding material instead of flushing all manure into liquid storage. Collection of manure as a slurry increases the nutrient density and reduces the volume of material needed to be transported off farm. Typically, a collected slurry will require additional treatment to remove moisture and yield a more transportable form.

Various scientists and companies have attempted use of chemical additives to improve solid liquid separation. Chemicals (Alum, other acids or poly acrylomide) are added to manure to enhance formation of flocculants. The laboratory work looked promising; however, on-farm work has been less promising. High amounts of previously soluble P can be incorporated into these small manure flocs. The flocs must be managed to obtain the maximum amount of P removal. This system is not beneficial for salt removal. Few individuals have evaluated potential total and component N removal. There are some commercial ventures utilizing flocculation or precipitation followed by dissolved air flotation (DAF). At this point in time, these are still in the experimental phase for dairy manure.

Greater attention is devoted to more detailed biological systems. Enhanced biological phosphorus removal (EBPR) as a nutrient removal technique for dairy manure is being evaluated (Yanosek et al., 1993). These researchers identified that acetic and propionic acids are a critical factor in EBPR. These acids are the preferred energy source for phosphorus accumulating organisms, the organism responsible for EBPR.

Composting manure can be a useful tool to improve farm nutrient balance. Benefits of on-farm composting include improve manure handling, decrease manure hauling costs, improve land application ability, stabilize N, decrease weed seed viability, decrease reduced risk of pollution and nuisance complaints, and pathogen destruction. Drawbacks of compositing include atmospheric emissions of gaseous compounds, loss of N, and resource utilization (labor, equipment and land must be dedicated to this activity to maintain a consistent product). The nutrient concentration of P and salts will increase as volume of the compost material decreases, although the actual quantity of these elements should remain unchanged. An excellent resource for on-farm composting is available (Rynk, 1992).

Anaerobic digestion. The key objective of anaerobic digestion is to collect and degrade organic material (solids) in an anaerobic environment, capture the methane gas and convert it to electricity. The chemical composition of methane is CH_4. The other major gas that is yielded during anaerobic digestion is carbon dioxide (CO_2). Anaerobic digestion in a controlled environment can be beneficial to reduce odor. Gases are formed within a structure (not released to the atmosphere) and at a pH near 7. At pH 7 methane production should be near optimum and there should be minimal formation of malodorous compounds. Gases formed are burned in the combustion process. Anaerobic digestion is not beneficial for a treatment technology if you need to reduce total N, P or salts.

If you are considering installation of anaerobic digestion treatment technology on your dairy, do your homework first. Identify appropriate vendors and determine if your facility is able to accommodate this type of technology. The US EPA maintains a website for location of vendors, equipment, etc. http://www.epa.gov/agstar/resources.html . Another great source of information is On-Farm Biogas Production- NRAES-20. It can be ordered from the Northeast Regional Agricultural Engineering Service, 154 Riley-Robb Hall, Cornell University, Ithaca, NY 14853.

Legget et al. prepared an extension publication on anaerobic digestion. They identified the following questions to ask prior to considering anaerobic digestion: Is manure currently handled as a liquid? Are little amounts of bedding or frozen manure handled? Is the manure in the handling system free from high levels of copper sulfate and antibiotics? Is odor control a major concern? Is there space on the farm to expand the manure handling system with the possibility for gravity flow from a barn to an anaerobic digester or from a digester to a manure storage structure? Does someone on the farm have the interest, time, and technical skills to learn about the anaerobic digestion process, make repairs, and perform general maintenance on equipment? Are resources available to finance an anaerobic digestion system? Can you adhere to the recommended safety practices?

Gasification of manure is receiving greater attention from commercial companies. The primary objective is the destruction of manure without causing air pollution. The remaining ash is of high quality. The end disposition of the ash is yet defined. This type of technology should contain N, P and salts in the ash.

Numerous companies are making headway into the manure treatment world. Many more will venture forth. Companies may provide a proprietary technology for your use (they maintain ownership) and they own and are responsible for the end product. Other companies have a turnkey system to treat your manure. Some of these are in the development stage. Others have a long (positive or negative) track record. The most detailed list of effectiveness of treatment technologies was prepared (Humenik, 2001).

9. Acquire more land. Addition of land may provide opportunity for more application of manure. This is often very expensive and may not be feasible. In some watersheds, adjacent land is saturated with P and purchase of it will not necessarily improve the land application ability.

10. Reduce herd size. Relocation of animals away from the farm clearly alters the nutrient balance at the farm.

Summary

If the nutrient imports to your operation exceed the nutrient exports from your operation there is need to given considerable thought to nutrient management. Identify your specific goals and carefully evaluate your options to achieve these goals. There is an immediate need for large dairies (defined by Federal regulation at 700 milking and dry cows or more) to address nutrient management.

Do your homework FIRST if you chose to use an advanced treatment technology. It is critical to understand your responsibility and the responsibility of the company. It is also critical to define in writing the party responsible for compliance required paperwork to document nutrient removal. Ask questions and talk with people to verify the legitimacy of the company and its technology. Check research results and be sure these were done at commercial scale and with dairy manure similar to the manure at your facility.

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