

Environmental issues affecting calf and heifer growers: What do you need to know?

W. J. Powers, Ph.D, Department of Animal Science, Iowa State University, and K. F. Knowlton, Ph.D., Department of Dairy Science, Virginia Tech

Water quality regulations

Federal CAFO regulations

The 1972 Clean Water Act defined confined animal feeding operations (CAFO's) as point sources of pollution, requiring them to obtain National Pollutant Discharge Elimination System (NPDES) permits. States were given the opportunity to enforce this act in place of the EPA as long as their regulations were at least as strict as the federal standards. Many states took on the job of creating their own regulatory programs, but some have not enforced the provisions of the Clean Water Act as strongly as the EPA would like.

Using EPA's definition of a CAFO, there were 6,600 CAFO's in the country in 1995. Of those, just 1/3 had the permits required by the Clean Water Act. At the same time, pollution of the country's streams, rivers, and lakes is increasingly being attributed to animal agriculture. Water quality has improved since the passage of the Clean Water Act, due largely to improvements in point sources of pollution (factories, sewage treatment plants, etc.), but 40% of the nation's waterways remain polluted.

The bulk of the remaining pollution is due to non point sources, including agriculture as well as runoff from city streets and other diffuse sources. Surveys of water quality are conducted by the states every two years, and sources of impairment are identified. In these surveys, agricultural practices have been identified as a source of pollution in 50-60% of the lakes, ponds, reservoirs, streams, and rivers in the country. These numbers are difficult to obtain, and are frequently subject to criticism and debate. What is clear though is that some livestock operations do contribute to water pollution.

Does my farm qualify as a CAFO?

A CAFO is defined as an operation that confines livestock (for feeding, milking, maintaining, etc.) in an area that is not covered by any vegetation for a total of 45 days in any 12 month period, collects and stores liquid waste, and meets certain size criteria. Regulatory agencies don't want to time cows to see how long they are in the milking parlor or being fed under confinement, so in most states, if animals are confined (i.e., on a bare feed lot or concrete floor) for any part of the day, they are considered confined for the entire day. The process of milking is considered confinement.

The second part of the CAFO definition focuses on farms that handle liquid waste. Manure handled as a liquid or slurry is obviously considered liquid waste, but contrary to common perception, farms that handle manure in a dry form are not off the hook. Milking center waste (waste milk and water to wash equipment) is generated on all dairies, and is considered liquid waste. In most states, stand-alone heifer operations are not currently required to have a permit if they do not generate liquid waste. This will soon change (see "Proposed changes", below).

The third factor defining whether dairy farms are considered CAFOs is the size of the herd. Current federal regulations define a CAFO as one with 1000 animal units (AUs), or 700 lactating cows (one AU = 1,000 lbs liveweight). There is variation between states in this definition, with some regulating farms with more than 300 animal units, some including animals per acre in the definition, and at least one state (Maryland) including virtually all farms (all farms with more than 8 AUs).

There has been much discussion over how to calculate the number of AU equivalents. Some states count only lactating cows, while some include all animals. Some states use the ratio of 1.4 AUs per mature dairy cow, regardless of breed, while others adjust for breed. In most states, AUs for other confined groups (i.e. heifers, calves, etc.) are calculated using the equation (Average animal weight, lbs./ 1000 lbs.) x total animals in group = Total AUs in group.

Proposed changes to Federal CAFO regulations

One of the last things the Clinton administration did before leaving office in December 2000 was to propose revisions to national CAFO regulations. Specific changes proposed include:

- Elimination of the 25 year, 24-hour storm permit exemption. Currently, large farms are not considered CAFOs if they only discharge during a 25 year, 24 hour storm event. This exemption offers farmers some protection from liability for the results of catastrophic storms or hurricanes.
- Requiring covered storage of swine and poultry wastes to eliminate storm water contamination
- Including dry manure-handling poultry operations. These were previously exempt as they did not handle liquid waste.
- Including stand-alone swine nurseries and heifer operations, with a subcategory for veal operations
- Requiring liners in storage lagoons on beef and dairy farms with a hydrologic link between ground water and surface water
- Requiring that integrators obtain permits to share liability with their producers
- Defining CAFOs as either
 - All farms with more than 500 AUs (“two tier structure”), or
 - All farms with 1000 AUs and some farms between 300 and 1000 AUs
- Requiring all CAFOs to have a site specific Permit Nutrient Plan
- Increased record-keeping and inspection requirements for CAFOs
- A move toward P-based nutrient management for CAFOs

These proposed changes are controversial. In August, 2001, the EPA issued an economic impact study estimating that the proposed CAFO regulations would cause 7-8% of all CAFOs to go out of business (1,900 to 2,400 farms).

Will these changes stick now that Bush is in the White House?

With the changing administration in Washington, D. C. came changes in philosophy and new approaches to solving environmental problems. Observers have noted a general shift in emphasis with regard to federal environmental regulations. The most obvious change is that economic impact is now a much greater part of the discussion on environmental programs. In her six month report, EPA administrator Christie Whitman began her list of significant

environmental accomplishments with the slogan “Energy Production and Environmental Protection – Perfect Together”. The report emphasized the President's philosophy of promoting market-based solutions to environmental challenges, and continually linked environmental protection, energy production, and economic prosperity. This emphasis on economics indicates a clear shift in priorities from the previous administration.

Another sign of this change in emphasis is the background of the people in charge of developing and implementing regulations. Many of the cabinet and sub-cabinet positions in both the Department of the Interior and the EPA have been filled by industry lobbyists, or those critical of traditional environmental organizations. In the Clinton administration, these positions were usually held by people who'd previously worked as environmental advocates.

A second change in emphasis by the current administration compared to the last one is an overall move to decrease federal involvement in environmental regulation, and to shift more of these responsibilities to the states. This administration's goal is to provide more grant dollars (and more flexibility) to the states for the development and implementation of environmental programs. At the same time, the President has proposed cutting the federal EPA enforcement staff by 8%, or 270 positions.

In addition to these changes in emphasis the Bush administration has delayed implementation of various regulations. The comment period on the new federal CAFO regulations was extended to allow industry and environmental groups more time to express their opinions. The comment period ended July 30th 2001, and 12,000 comments were received. The EPA is required to take final action on these rules by December 15th, 2002, but what these federal CAFO regulations will look like in the end is still unclear. For more information, see this website (active at the time this article went to press) http://cfpub1.epa.gov/npdes/afo/caforule.cfm?program_id=7 .

TMDLs

One of the most-used phrases in water quality discussions these days is TMDL, or Total Maximum Daily Load. A TMDL is a goal, a target load of a specific pollutant that a specific stream segment can absorb on a daily basis without impairing a beneficial use (i.e., aquatic life, human recreational activities, human consumption, municipal uses). The phrase is also used to describe the plan to restore impaired waters.

The concept of TMDLs was first laid out in the 1972 Clean Water Act. The EPA was to direct states to establish TMDLs for all streams and rivers in the state, publish lists of impaired stream segments, and develop plans for returning impaired waters to unimpaired status. If the states did not submit these TMDL plans, or if they submitted unacceptable plans, EPA was to take on the responsibility for developing TMDLs. Very little was done with this through the 1980's as the EPA focused on reducing pollution from industrial sources and municipalities.

The EPA became active in the development of TMDLs in response to lawsuits filed by environmental organizations in several states. In these lawsuits, environmental organizations alleged that EPA had failed to fulfill the requirements of the Clean Water Act as they had neither pushed states to develop TMDLs nor taken on responsibility for developing these TMDLs themselves. In eighteen states, court orders have been handed down against EPA. In eleven other states, lawsuits have been filed or the intent to sue has been declared.

What is involved in developing a TMDL?

Each state publishes a TMDL list, identifying bodies of water that are impaired with regard to pathogens, sediments, nutrients, or benthic communities (aquatic wildlife). A TMDL for a specific pollutant (i.e., coliform bacteria, nitrates, benthics) involves quantifying the capacity of a specific stream segment to incorporate that pollutant and adapt without negative impact. Predictive modeling is then used to quantify the allowable level of pollution for that stream segment. Sources of the pollutant are identified, and allowable pollution is allocated among sources. The allocation of the TMDL is to be specific (i.e., to a specific facility or farm).

Each TMDL must account for seasonal variability, and must include a margin of safety to account for uncertainty (typically 5-10%), and an allowance for future growth. If the population is predicted to grow by 20%, or the town planners anticipate that processing plants may move into the area, they must “save room” for them in the TMDL.

Challenges

Some of the challenges facing those developing TMDLs are obvious. How do you determine who or what is the source of the pollutant? If the stream is impaired because of excessive coliform bacteria, for instance, are those coliforms from faulty septic systems, from livestock in the stream, or from wildlife?

Allocation of the load (i.e., who can continue to load pollutants to the stream and at what levels) is also a contentious issue. Industry is afraid they’ll be assigned too much of the blame for pollutant loads, and farmers are afraid they’ll be asked to make too many drastic changes without enough cost-share funding. And how do you predict how much of a pathogen or nutrient will be produced by industry that may one day move in to the region?

In addition, there is controversy in many states over the standards being used to determine what waters are impaired. Prior to TMDL’s, many states did not enforce ambient (in-stream) water quality standards for nutrients and pathogens. The focus was on monitoring drinking water quality, and on implementing technology to reduce discharge of pollutants from factories and municipalities. The standards in place for these traditional regulations are often much stricter than most scientists think necessary for ambient water quality.

Finally, while the list of impaired waters is a list no one wants to be on, it’s much easier to get on the list than to get off of it. In Virginia, for example, a stream is considered impaired if 10% of the water samples taken over a period of time are in violation of the fecal coliform standard. For a stream to be removed from the list of impaired waters, however, there must be **zero** violations of the standards, regardless of extreme weather or other unusual circumstances.

A handful of TMDLs have now been completed in Virginia, and the process has been instructive. The TMDLs developed so far have several things in common. All the fecal coliform TMDLs have called for 90-100% reduction in cattle access to streams. All direct pipes from dairies and homes have been eliminated. All plans have required improved manure management (storage, nutrient management plans, buffer strips, etc.). Farmers and other landowners appear to be “buying in” to this process, as long as they receive adequate technical and financial assistance to implement these changes.

One quite unexpected result of this first round of TMDLs is that in some watersheds, the only way to ensure that a stream would have no violations of the coliform standard was to reduce

wildlife access to streams!! In many states, the current standards make no allowance for natural or background contamination – zero violations means zero violations. This finding has led to serious discussion of whether these standards are truly feasible.

What does the future hold?

All told, there are 21,000 impaired waterbodies (streams, rivers, lakes) in the United States. These represent 300,000 miles of impaired river and shorelines, and five million acres of impaired lakes. Some of these waterbodies are considered impaired for more than one pollutant, so the number of TMDLs to be developed is 40,000. This number could (and likely will) increase as increased monitoring identifies more and more impaired waterbodies.

The change in administration is, as discussed earlier, affecting many regulations, and implementation of the TMDL rules have been delayed. The final TMDL rule was passed by the Clinton administration in July, 2000 to improve the national TMDL program, and was scheduled to go into effect in October, 2001. This rule was challenged by many farm groups in the courts as unrealistic, and in August of 2001, the EPA released a study indicating that implementing the TMDL rule would cost between \$900 million and \$4.3 billion per year. The EPA then postponed implementation of this rule for 18 months to make it more “workable”.

Nutrient management planning concepts

Whole-farm nutrient management planning

Environmental accountability requires that livestock producers formulate a nutrient management plan, or budget that includes: 1) number of animals to be produced, 2) estimated nutrient excretion, 3) nutrients recovered and applied for fertilizer (based on manure analyses), 4) crop removal of nutrients, and 5) a plan to export nutrients off-farm if there is excess manure nutrient production relative to on-farm crop production needs. Without any one of these components, a budget can not be achieved. Proposed budgets for example operations are available (Van Horn et al., 1994). Figure 1 illustrates the concept of whole-farm nutrient budgeting for heifer operations. Based on manure makeup and the overall management program, a producer can make the necessary alterations to achieve a properly balanced operation.

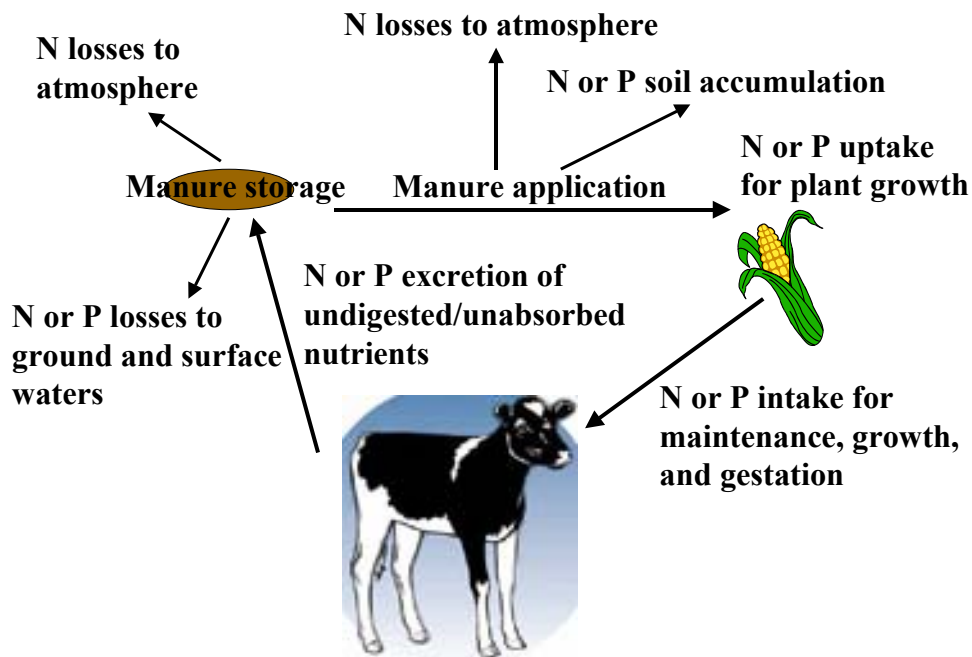


Figure 1. Pictorial illustration of whole-farm nutrient budgeting for heifer operations.

Input-Output Relationships to Estimate Nutrient Excretion

In a nutrient management scheme, a key point available to manipulate the budget is at the manure source. By minimizing manure quantity and nutrients excreted, manure may be more easily managed through reduction of storage needs and acreage required for nutrient utilization. Manure production is influenced by the diet consumed, thus nutritional strategies to optimize manure production should be employed.

Digestibility is considered to be the percentage of the dry matter or particular nutrient in the diet that the animal could absorb from its digestive tract and have available to use for maintaining life and producing offspring, body weight gain, milk, eggs, wool, etc. By definition, apparent digestibility is the difference between amounts fed and amounts recovered in feces. Previous nutrition research has given us good estimates of apparent digestibilities of ingredients that can be combined to estimate total ration digestibilities. Farmers, often with help from a consulting nutritionist, formulate rations of known digestibility for animals based on performance expected from those animals.

Knowing digestibility and, hence, indigestibility of the ration dry matter and organic matter permits us to estimate the amounts of dry matter and organic matter excreted, components that determine manure volume.

When animals are accumulating N, P, and K in body weight gain, offspring, or milk or eggs produced, the amount of those nutrients excreted in manure (feces plus urine) differ from what is fed by the amounts in products produced. Excreted amounts of nutrients are diluted in the indigestible residue of organic and mineral matter in manure and variable amounts of water excreted in urine and feces. Nutrition-based models also allow for production level

consideration. Faster-growing animals require greater feed intake to support greater rates of gain and nutrient accretion thereby excreting more manure as a percent of bodyweight. Thus, nutrition-based data coupled with good estimates of the nutrient content of gain permit accurate estimation of total nutrient excretions in feces plus urine by difference (Watts et al., 1994).

Manure changes in composition after excretion as a result of ammonia volatilization and volume reduction due to carbon dioxide and methane losses. Estimates of nutrient losses during manure storage and in pastures are provided in table 1. Manures usually are P-rich relative to N because N:P ratios recommended in plant fertilizers usually are much wider, e.g., 9:1. Calculated ratios in freshly excreted manure, although still P-rich, are much closer to plant needs. If N volatilization losses can be eliminated or greatly reduced and/or P excretion reduced, manures would be much closer to a complete fertilizer. If it becomes possible to reduce dietary P and still meet minimum animal requirements and to reduce N volatilization, production of manures with N:P ratios of 8:1 or greater, as needed in plant fertilizers could result. Because manures become more and more P-rich as more N volatilizes, ration management to minimize dietary P concentrations will become especially important. However, surveys indicate (e.g., Shaver and Howard, 1995; Watts et al., 1994) that dairy and beef producers usually feed more dietary P than animals require and, thus, excretions can be reduced by dietary reduction.

By combining improved digestibility and optimal dietary nutrient content, nutrient and volume reduction, reductions in storage capacity and acreage for crop growth can be realized, resulting in reduced capital investment costs. By optimally balancing the diet offered, manure production and composition can be altered. Offering a diet that most nearly meets the animals' needs without providing excess nutrients is the key to reducing manure nutrient concentrations.

Crop uptake

Nutrient needs of most crops are well established. By knowing the yield and the nutrient requirement per unit of yield, crop uptake of a given nutrient can be estimated. As part of a whole-farm nutrient management plan, these estimates must be made for crops and/or pastures where manure will be applied. Table 2 provides estimates of N, P₂O₅, and K₂O needs for common pastures, forages, and row crops.

Manure Exports

In the event that insufficient land is available through ownership or rental, plans must be included to accommodate manure nutrient excesses. This may require agreements with third parties to receive these nutrients. Nutrients may be exported in the dry form as a soil amendment, or, in some cases, as slurry. Recycling of dry solids for use as bedding material also will help reduce acreage requirements. Recycling solids as a feed source, though not widely implemented, can serve as an additional mechanism. The idea of centralized manure processing facilities (burning, pelleting, methane generation) also is gaining popularity as a method of accommodating animal production in land-limited conditions.

Table 1. Estimated nutrient losses during manure storage followed by application and in pastures.

Storage method		Nitrogen lost, %
Solid	Daily scrape and haul	15-35
	Manure pack	20-40

Liquid	Open lot	40-60
	Deep pit (poultry)	15-35
	Anaerobic pit	15-30
	Above-ground storage	10-30
	Earthen storage	20-40
	Lagoon	70-80
Application method	Type of manure	
Broadcast	Solid	15-30
	Liquid	10-25
Broadcast with immediate cultivation	Solid	1-5
	Liquid	1-5
Knifing	Liquid	0-2
Sprinkler irrigation	Liquid	15-35
Pastures (grazing)		20-50

From: Livestock Waste Facilities Handbook. MWPS-18. 1985. Midwest Plan Service, Ames, Iowa.

Table 2. Crop usage rate factors of common pastures, forages and row crops.

Crop	Units	N	P ₂ O ₅	K ₂ O
			Pounds/unit	
Corn grain	bu	1.1	0.4	0.3
Corn silage	ton	7.5	3.5	6.5
Soybeans	bu	3.8	0.8	1.5
Oats	bu	0.75	0.4	1.0
Wheat	bu	1.3	0.6	0.3
Alfalfa	ton	50	12.5	50
Smooth brome	ton	40	9	47
Orchardgrass	ton	38	14	68
Tall fescue	ton	38	12	66
Switch grass	ton	21	12	66
Sorghum-sudan	ton	40	12	38
Vetch	ton	56	12	47
Red clover	ton	43	10	33
Perennial ryegrass	ton	24	12	34
Timothy	ton	25	9	32
Wheat straw	ton	13	4	25
Oat straw	ton	12	5	33

Reducing P losses through nutrition

The challenge facing the dairy industry is to identify cost-effective techniques to reduce the environmental impact of farming operations while maintaining their economic viability. Most efforts to reduce nutrient losses from farms have focused on manure management: handling nutrients once they accumulated on the farm. Relatively little attention has been paid to the “front end” of the system: management of the herd and feeding program to minimize nutrient excretion. Better understanding of the P requirements of dairy cows, and reducing the P content

of diets to true requirements will reduce P excretion, a critical step in addressing the nutrient imbalance that occurs on most farms.

Phosphorus requirements

Phosphorus is required by dairy animals for bone formation and maintenance, milk secretion, building muscle tissue, energy metabolism, fatty acid transport, phospholipid synthesis, amino acid metabolism, and protein synthesis. It is a component of nucleic acids involved in cellular metabolism, enzyme systems, and buffer systems.

Regulation of P metabolism involves regulation of absorption from the gut, mobilization from bone, and secretion in saliva. Phosphorus is absorbed in the small intestine as phosphate, and this absorption is primarily in response to need – low serum P increases absorption of dietary P (Hibbs and Conrad, 1966; National Research Council, 1974; Preston et al., 1977; Hibbs and Conrad, 1983; Miller, 1983). Phosphorus in the bloodstream is either retained in meat, milk, or bone, or secreted through saliva back to the digestive tract. Ruminants secrete large quantities of P in saliva, and this is a key mechanism for the regulation of P metabolism. Absorbed P not used for growth, deposited in bone, or secreted in milk is secreted in the saliva and then excreted in the feces.

Requirements for P in growing heifers are the sum of requirements for maintenance, growth, and pregnancy (for bred heifers in the last 2 months of pregnancy). Minerals in feeds are not completely available to the animal, however, so this absorbed requirement must be adjusted for the availability of that mineral in feeds. Table 3 outlines the dietary P requirement of heifers of varying body weights and rates of gain (National Research Council, 2001).

In the new NRC, the maintenance requirement for P is related to the DMI of the animal, with some urinary loss associated with body weight. The relationship to DMI makes sense, as nearly half of the inevitable fecal loss of P is from microbial cells, and increased DMI influences microbial growth. This is a change from the previous NRC publication, however, which related maintenance requirement for P entirely to body weight (National Research Council, 1989).

The requirement of P to support growth is the sum of that needed to support growth of soft tissue, and that needed to support growth of bone. Young animals require more P per pound of body weight gain than do older animals because of their more rapid skeletal development. As with other nutrients, the requirement for P to support pregnancy is only significant in the last two months, and so an exponential equation is used based on a comprehensive study of body composition of pregnant dairy cows done at Cornell in the early 1990's.

This total absorbed requirement for P must be adjusted for the availability of feed P to the animal. This version of the NRC is the first to attempt to assign separate availability coefficients for each mineral to forages, grains, and mineral supplements. These availability coefficients reflect the fact that the P in corn silage may not be as available to the animal as the P in dicalcium phosphate, for instance. After reviewing the literature, the 2001 NRC committee concluded that the availability of feed P is 64% for forages and 70% for concentrates. Availability of P in mineral sources ranges from 75% for dicalcium phosphate to 80% for ammonium phosphate and 90% for monosodium phosphate. Two factors that research results indicate do **not** affect the availability of dietary P are phytic acid-P, and the Ca:P ratio.

Table 3. Dietary P requirements (% of diet DM) for heifers of varying body weight and growth rate. (National Research Council, 2001)¹

BW, lbs	Average daily gain, lb/d							
	0.7	0.9	1.1	1.3	1.5	1.8	2.0	2.2
220	0.23%	0.27%	0.32%	0.35%	0.39%	0.42%		
330	0.20%	0.24%	0.27%	0.29%	0.31%	0.36%	0.38%	0.40%
441	0.20%	0.22%	0.24%	0.25%	0.27%	0.29%	0.33%	0.35%
551	0.19%	0.20%	0.22%	0.23%	0.25%	0.26%	0.27%	0.29%
661	0.18%	0.19%	0.20%	0.22%	0.23%	0.24%	0.25%	0.27%
771			0.19%	0.21%	0.22%	0.23%	0.24%	0.25%
881			0.19%	0.20%	0.21%	0.22%	0.23%	0.24%
991 ²			0.24%	0.24%	0.25%	0.26%	0.27%	0.28%
1101			0.23%	0.24%	0.24%	0.25%	0.26%	0.27%
1211			0.22%	0.23%	0.24%	0.24%	0.25%	0.26%
1322			0.22%	0.22%	0.23%	0.23%	0.24%	0.25%
1432			0.21%	0.22%	0.22%	0.22%	0.23%	0.24%

¹Assumes DMI as predicted in tables 14-12, 14-13, 14-14, and 14-15 (National Research Council, 2001)

²Values for heifers 991 lbs and larger include pregnancy requirements.

Dietary P and P excretion

The 2001 NRC P requirement for lactating dairy cows is about .34 to .40% of diet DM, but P content of lactating cow rations in the field typically averages .50% or greater, 30% more P than required (Sink et al., 2000). Phosphorus is often fed to dairy cattle in excess of published requirements because high P diets are commonly believed to improve reproductive performance. This perception likely originates from the observation that severe P deficiency impairs reproductive performance in cattle. The original studies that established this belief were primarily with range cattle (Eckles et al., 1932; Beeson et al., 1941), and the dietary P concentrations necessary to induce this impaired reproductive performance were below 0.20% of the dietary DM for lactating cows. This dietary concentration is far below the concentration found in most feedstuffs in modern lactating cow rations even without supplementation, and in all of these studies, P intake was seriously confounded with intake of energy and other minerals.

Although severe P deficiency may impair reproductive performance, there is no research data to suggest a benefit from feeding P to dairy cows in excess of NRC requirements (Brodison et al., 1989; Brintrup et al., 1993; Wu et al., 2000). An important point to emphasize is that like other nutrients, the requirement of the animal for P is for absorbed quantities of P, not dietary concentrations. For convenience in balancing rations, P requirements are commonly expressed as a percentage of DM. The actual dietary concentration required to yield the required quantity of P, however, varies with dry matter intake and feed source. For instance, the current NRC requirements for a 1320 lb cow producing 80 lb/d of milk is ~56 g of absorbed P per day. The percent P required in the diet DM for this cow is .37% to .33%, as DMI varies from 45 to 55 lb/d.

Again, field observations suggest that most dairy farmers feed diets containing P significantly in excess of these published requirements. Two factors that have led farmers to overfeed P are undetected variation in the P content of feeds, and inconsistencies between NRC requirements and the advice farmers receive. Undetected variation in the P content of feeds leads to imprecise ration formulation. Phosphorus content of forages analyzed by the Northeast DHI Forage laboratory from May 94 through April 95 was highly variable (Kertz, 1998). The coefficient of variation in P content of forages was 20-25% for most forage types, and P content was more variable for grasses than for legumes. Despite this variation, wet chemistry analysis of forages for P content is not routinely requested.

Both ration balancing programs and field recommendations influence P intakes in the field. Although based on NRC, the DART ration balancing software lists P requirements about 15% higher than NRC for lactating cows (Eastridge et al., 1998). This inconsistency, and inconsistent recommendations from nutritionists, veterinarians, and extension personnel have led many farmers to feed P in excess of the NRC recommendations. Until the environmental consequences became obvious, overfeeding P was viewed as cheap reproductive insurance. Revisiting the literature makes clear that there is no documented benefit to overfeeding P. Now that we are realizing the true cost of overfeeding P, we must move aggressively to correct inconsistencies in our recommendations. Phosphorus intakes in the field are now typically in excess of current requirements by 25-40%, giving farmers a tremendous opportunity to benefit both economically and environmentally by feeding at the current published requirements.

BMPs for confinement operations

In addition to the nutritional strategies described above, there are a variety of best management practices (BMPs) heifer growers and other dairy producers can use to minimize the impact of their operations on water quality. While a complete discussion of these BMPs is beyond the scope of this paper, some key ones are listed below.

Manure handling & storage

- Maintain a manure storage facility with capacity sufficient to prevent application of manure to frozen or saturated ground (six to eight months in northern states).
- Sample and analyze manure from each manure storage facility annually.
- Gutter roofs, and divert clean water from manure storage facility to reduce needed volume of manure storage.
- Completely contain barnyard runoff.
- Consider solid-liquid manure separation to improve handling characteristics of excreted manure.
- Consider composting manure solids to reduce volume, and odor and N content of land-applied manure. Good management of the composting facility is critical, however, and costs and benefits of composting operations must be analyzed carefully.

Land application & cropping strategies

- Develop and implement a comprehensive nutrient management plan.
- Implement crop fertilization practices that enhance utilization of manure nutrients.
- Use buffer strips around fields to filter sediment and nutrient runoff.
- Sample and analyze soils every three years.

- If exporting manure, maintain records of manure transferred, and provide recipients with information about nutrient management planning.

BMPs for pasture-based operations

Recommended practices for pasture operations focus on both animal and pasture management. Animal management practices include the following:

- Know the nutrient composition of the pasture and supplement minerals as needed. This may require a custom mineral supplement to avoid overfeeding phosphorus. In addition, this may require frequent pasture sampling
- Locate waterers and shade areas separately to avoid having animals concentrate around waterers, making the area muddy
- Fence animals away from water supplies that are not contained in the pasture. The Clean Water Act prohibits CAFO animals from having access to ‘waters of the state’, or, those waterways that do not start and end on the producer’s property.
- Do not overstock pastures. In a pasture system nutrients excreted in manure provide sufficient phosphorus to grow approximately 90% of the grass needs for growing dairy cattle. Therefore, such systems are considered sustainable. In fact, some additional nitrogen and phosphorus fertilizer is needed if all intake is provided from pasture. However, overstocking pastures or providing a considerable portion of intake from non-pasture sources can result in greater manure phosphorus than is needed for the pasture.

Pasture management practices that are recommended include:

- Implement pasture fertilization practices that enhance distribution of manure nutrients throughout the pasture. This improves pasture performance as well as promotes environmental stewardship.
- Incorporate riparian buffer areas between pastures and waterways. The buffers function to filter sediment and phosphorus that moves off of sloping pastures.
- Adopt grazing practices, such as rotational grazing and winter stockpiling, that retain groundcover to avoid sediment and nutrient losses.

Emerging issues and BMPs

For the past several years much of the activity addressing environmental issues associated with animal production have focused on the revision of the Clean Water Act via the USEPA/USDA Joint Strategy for Animal Feeding Operations. However, as the strategy has evolved we have seen discussion within the proposed documents on air quality. Clearly the move towards addressing air quality impacts of animal feeding operations has gained momentum as a result of nuisance and human health concerns. In the Clean Air Act amendment of 1990, EPA was required to establish National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to human health. As a result, primary standards were established to protect public health while secondary standards were established to protect public welfare (e.g. decreased visibility, damage to crops, animals, buildings).

In addition to gaseous emissions, particulate matter (PM) was included in the standards. Particulate matter poses perhaps the greatest challenge for animal agriculture. Direct emission sources of PM₁₀, the coarse particulates, arise from primarily combustion processes (EPA, 1998).

Direct emissions of PM_{2.5}, respirable particulates, are also primarily the result of combustion processes (EPA, 1998). In addition to direct emissions, secondary processes, whereby SO_x, NO_x, and NH₃ react in the atmosphere to form ammonium sulfate and ammonium nitrate fine particles, contribute to as much as half of the PM_{2.5} measured in the U.S.

The EPA estimates that 86% of the national ammonia emissions are from miscellaneous sources that includes livestock and fertilizer (EPA, 1998). Livestock agriculture accounted for 83% of all emissions in the miscellaneous category with fertilizer application comprising the remainder. The EPA already regulates many combustion processes through industrial and utility permitting processes. Area sources are not likely to be targeted for future regulation because they are non-point source emitters. To address particulate emission reductions animal agriculture is a likely target due to its contribution to ammonia emissions which, in turn, can contribute to up to half of particulate concentrations and emissions. Recall that Concentrated Animal Feeding Operations (CAFOs) are point source emitters. And under the current proposed revisions to the Clean Water Act, stand-alone heifer operations will be included as Animal Feeding Operations. The threshold to receive CAFO designation may be reduced to as low as 500 animal units. Therefore, some dairy heifer growers could be impacted. Animal agriculture must be taking steps to address ammonia production and emission.

VOCs and human health

While odor has generally been considered a nuisance, there is considerable interest in determining the human health impacts of livestock operations, particularly confinement operations. Some states have pursued this issue through state and local boards of health. In addition, the EPA has commissioned the National Academy of Science to conduct a study investigating the state of the science on this issue. While the research is limited, the continued rise in number of people afflicted with asthma and the perceived notion that something that smells offensive 'can't be good for you' will propel the issue. Producers must be kept aware that in addition to worker safety issues, as overseen by OSHA, concerns over downwind human health impacts will not go away anytime soon and, in fact, will likely draw greater attention.

Management strategies and Best Management Practices

Ammonia formation in manure is the result of the cleavage of urea, excreted in the urine, by urease, which is excreted in the feces. Undigested protein and wasted feed are additional sources of ammonia in animal production systems. In cattle and pigs, 50 to 80% of total nitrogen excreted is in the urine and greater than 70% of the nitrogen is as urea-N (Van Horn et al., 1996; Bristow et al., 1992). Below a pH of 7, ammonia occurs almost exclusively as NH₄⁺ and will remain in solution thereby preventing volatilization as ammonia gas. Factors contributing to the rate of ammonia volatilization are the concentration of urea and ammonia/ammonium in the manure, temperature and air velocity, surface area, and moisture (Lenis and Jongbloed, 1999). Ammonia contributes not only to the potential for PM_{2.5} formation but also, to soil acidification and eutrophication. A review by Meisinger and Jokela (2000) partitioned system losses of ammonia into land application (35-45%), manure storage (5-15%), housing (30-35%), and during grazing (10-25%). This suggests multiple opportunities to curtail ammonia losses to the atmosphere, with the greatest potential gains from strategies that reduce ammonia emissions during land application and from the housing facilities.

Best Management Practices to address emerging issues

Pre-excretion strategies focus on nutritional strategies to more nearly meet animal nutrient needs without exceeding those needs. Further considerations that warrant additional research include dietary addition of pH modifiers and urease inhibitors to reduce ammonia volatilization following excretion.

Post-excretion strategies to reduce volatilization of ammonia during housing have included urease inhibition, separation of urine and feces, and pH modification of excreta. Each of these methods warrants further investigation. Current recommended practices, post-excretion, include frequent scraping of lots and alleys, covering manure storages, and frequent incorporation and distribution of pasture manure.

Conclusions

While stand-alone heifer operations have been previously excluded from consideration as CAFOs, this may be changing under the proposed revisions to the Clean Water Act. In addition, state and local control measures may choose to encompass heifer operations under local regulations. As a result, it is imperative that growers be cognizant of what regulations exist and how their own operations may be impacted in the future.

How can I prepare for future environmental regulations?

1. **Learn, and become involved.** The development of environmental regulations is only accelerating. The key to protecting the environment while maintaining economic viability is for farmers to move away from fighting all regulations, and move toward defining and implementing cost-effective (or cost-shared) best management practices on all farms. The sooner producers begin to work together with consumer groups, government agencies, scientists, and environmental organizations to develop workable, effective environmental policies, the better off the industry will be.
2. **Improve management.** Direct discharges from septic systems, unlimited access of cattle to streams, and indiscriminant use of manure and fertilizers all increase nutrient losses from the farm to surface water. Improved management to avoid these practices is a critical first step to preparing to meet more stringent regulations.
3. **Implement needed BMPs.** Cost share funds of up to 75% for approved practices are available through various state and national agencies. One notable program is the Natural Resource Conservation Service's EQIP program. While CAFOs are not eligible for this program, heifer operations are, depending on state guidelines. More information is available from your local MRCS office or from their national website (www.nrcs.usda.gov/). For those who do not wish to accept cost-share funds, tax incentives are also available. Low interest rate loans are also available for the implementation of approved practices.

None of these are quick fixes, but over time, improved management will reduce the level of pollutants and ultimately lead to the removal of stream segments from the list of impaired waters. This improves the environment for both humans and animals.

References

- Beeson, W. M., D. W. Bolin, C. W. Hickman and R. F. Johnson. 1941. The phosphorus requirement for growing and fattening beef steers. Idaho Agric. Exp. Stn. Bull. no. 240 Moscow, Idaho State University.
- Brintrup, R., T. Mooren, U. Meyer, H. Spiekers and E. Pfeffer. 1993. Effects of two levels of phosphorus intake on performance and faecal phosphorus excretion of dairy cows. *J. Anim. Physiol. Anim. Nutr.* 69: 29-36.
- Bristow, A.W., D.C. Whitehead, and J.E. Cockburn. 1992. *J. Sci. Food Agric.* 59(3):1009-1022.
- Brodison, J. A., E. A. Goodall, J. D. Armstrong, D. I. Givens, F. J. Gordon, W. J. McCaughey and J. R. Todd. 1989. Influence of dietary phosphorus on the performance of lactating dairy cattle. *J. Agric. Sci.* 112: 303-311.
- Eastridge, M. L., H. F. Bucholtz, A. L. Slater and C. S. Hall. 1998. Nutrient requirements for dairy cattle of the national research council versus some commonly used software. *J. Dairy Sci.* 81: 3059-3062.
- Eckles, C. H., T. W. Gullickson and L. S. Palmer. 1932. Phosphorus deficiency in the rations of cattle. Minn. Agric. Exp. Stn. Tech. Bull. no. 91 St. Paul, University of Minnesota.
- EPA, 1998. National air pollutant emission trends, 1990-1998.
- Hibbs, J. W. and H. R. Conrad. 1966. Re-evaluation of nutrient allowances for high-producing cows. 2 calcium, phosphorus and vitamin d. *J. Dairy Sci.* 49: 243-246.
- Hibbs, J. W. and H. R. Conrad. 1983. The relation of calcium and phosphorus intake and digestion of calcium and phosphorus by lactating dairy cows. Ohio Agric. Expt. Stn. Wooster, Ohio State University.
- Kertz, A. 1998. Variability in delivery of nutrients to lactating dairy cows. *J. Dairy Sci.* 81: 3075-3084.
- Lenis, N.P. and A.W. Jongbloed. 1999. New technologies in low pollution swine diets: diet manipulation and use of synthetic amino acids, phytase and phase feeding for reduction of nitrogen and phosphorus excretion and ammonia emissions – review. *Asian-Aus. J. Anim. Sci.* 12(2):305-327.
- Meisinger, J. J. and W. E. Jokela. 2000. Ammonia losses from manure. *Proc. 62nd Cornell Nutr. Conf. Feed Manuf. Ithaca, N.Y.*, p. 109-116.
- Midwest Plan Service. 1993. Livestock Waste Facilities Handbook. MWPS-18, Ames, Iowa.
- Miller, W. J. 1983. Phosphorus nutrition, biochemistry, metabolism, and requirements in ruminants. Paper presented at the meeting of the National Feed Ingredients Association meeting, Chicago, IL, April 4-7.
- National Research Council. 1974. Feed phosphorus shortage. Levels and sources of phosphorus recommended for livestock and poultry. Washington D.C. National Academy of Sciences.
- National Research Council. 1989. Nutrient requirements of dairy cattle. 6th rev. ed. Natl. Acad. Sci., Washington DC.
- National Research Council. 2001. Nutrient requirements of dairy cattle. 7th rev. ed. Natl. Acad. Sci., Washington DC.
- Preston, R. L., N. L. Jacobson, K. D. Wiggers, M. H. Wiggers and G. N. Jacobson. 1977. Phosphorus in ruminant nutrition. In. *Proc. Natl. Feed Ingrid. Assoc.* West Des Moines, Iowa. National Feed Ingredients Association.
- Shaver, R. and W.T. Howard. 1995. Are we feeding too much phosphorus? *Hoard's Dairyman* 140(10 Apr):280.

- Sink, S. E., K. F. Knowlton and J. H. Herbein. 2000. Economic and environmental implications of overfeeding phosphorus on Virginia dairy farms. *J. Anim. Sci* 78 (Suppl. 2): 4.
- Van Horn, H.H., G.L. Newton, and W.E. Kunkle. 1996. Ruminant nutrition from an environmental perspective: factors affecting whole-farm nutrient balance. *J. Anim. Sci.* 74:3082-3102.
- Van Horn, H.H., A.C. Wilkie, W.J. Powers, and R.A. Nordstedt. 1994. Components of dairy manure management systems. *J. Dairy Sci.* 77:2008-2030.
- Watts, P.J., E.A. Gardner, R.W. Tucker, and K.D. Casey. 1994. Mass-balance approach to design nutrient management systems at cattle feedlots. *Proc. Great Plains Anim. Waste Conf. on Confined Anim. Prod. And Water Quality: Balancing Animal Prod. & the Environment.* GPAC Publ. No. 151. P 27. Great Plains Agric. Council, Fort Collins, CO.
- Wu, Z., L. D. Satter and R. Sojo. 2000. Milk production, reproductive performance, and fecal excretion of phosphorus by dairy cows fed three amounts of phosphorus. *J. Dairy Sci.* 83: 1028-1041.