Reducing nutrient losses from dairy farms

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Farmers across the country are increasingly feeling pressure to minimize the impact of their farm management practices on the environment. Implementation of nutrient management planning, cost-sharing for manure storage facilities, application for permits, and changing environmental legislation are frequent topics of conversation among dairymen and their advisors. The challenge facing the industry is to identify techniques to reduce the environmental impact of farming operations while maintaining their economic viability.

Nutrient pollution of ground and surface water is the primary environmental issue facing farmers in our region, as impaired water quality has been linked to losses of nitrogen (N) and phosphorus (P) from farms. Typically, efforts to reduce nutrient losses from farms have focused on manure management: handling nutrients once they accumulate on the farm. Little attention has been paid to the "front end" of the system: management of the herd and feeding program to minimize nutrient excretion. This article focuses on the opportunity farmers and their advisors have to reduce N and P losses from dairy farms through improved nutrition.

Why are we concerned about nutrient losses?

Increased specialization and concentration of crop and livestock production has led to the net transfer of N and P from major crop producing areas (i.e. the corn and wheat belt) into areas with a high concentration of livestock operations. While meat and milk exports from areas with strong livestock industries do take with them some of these imported nutrients, the majority of the N and P imported to these regions in feed are excreted by livestock and remain in the area. This concentration of nutrients in areas of intensive animal agriculture has been linked to current and potential water quality concerns. Examples include the DelMarVa peninsula with its concentrated poultry industry, North Carolina with its hog industry, and Lancaster County PA, the Chino Valley in California, and the Lake Okeechobee area in Florida all with a high concentration of dairies. The Chesapeake Bay watershed, stretching from New York to the Shenandoah Valley in Virginia, is another area where animal agriculture and water quality concerns have been linked.

Nitrogen

Environmental concerns associated with N include contamination of ground and surface water, and impaired air quality (ammonia). Nitrogen applied to land in excess of crop needs can runoff and contaminate surface water (streams, lakes, rivers, estuaries), and leach into groundwater and contaminate wells. Excess N in bodies of surface water causes algae populations to grow rapidly, or to "bloom". Decomposition of this algae consumes dissolved oxygen in the water, and this decreased dissolved oxygen decreases the population of fish, clams, crabs, oysters, and other animal life. An algae bloom and subsequent decrease in dissolved oxygen is known as eutrophication.

Nitrogen contamination of ground water is also of concern. Consumption of high nitrate water can cause a condition known as methemoglobinemia, where nitrite replaces oxygen in hemoglobin. With increased levels of methemoglobin, oxygen levels in the blood decrease, resulting in cyanosis, or oxygen starvation. This is particularly of concern with infants.

Finally, N can damage the environment in the form of ammonia. Dramatic increases in air concentration of ammonia in areas of intensive agriculture have been reported, and European studies indicate that animal agriculture accounts for anywhere from 15 to 75% of total ammonia volatilization. Ammonia has direct, toxic effects on vegetation, and when returned to soil and water by rainfall, disrupts ecosystems and leads to eutrophication.

Phosphorus

Environmental concerns with P are associated with pollution of surface water. Excess P in water, like excess N, causes algae populations to grow rapidly, or to "bloom", and the decomposition of this algae affects the survival and productivity of fish. Unlike N, P in soil is relatively stable, and doesn't leach to groundwater. Instead, it accumulates. Historically, P runoff has been primarily associated with soil erosion. With excessive application of P to soils over a period of years, however, it is becoming apparent that saturation of soils can lead to P runoff even when erosion is controlled. Still controversial, and the subject of much current research, is the soil

P level at which soluble P becomes a problem, and the interaction of soil type with P solubility and runoff.

Reducing N losses through nutrition

Recent research suggests real potential to reduce N losses from dairy farms (N runoff, leaching, volatilization) through nutrition. Feeding rations balanced for ruminally degraded and undegraded protein rather than total crude protein is one way to reduce N excretion. Feed protein may be degraded in the rumen, or may escape rumen fermentation and flow to the small intestine. The ammonia and amino acids from protein digested in the rumen will be used to synthesize microbial protein if sufficient energy is available, but otherwise will be absorbed. Some absorbed ammonia recycles to the rumen through saliva, but most is excreted in urine. Florida workers demonstrated that feeding diets balanced for degraded and undegraded intake protein to prevent excessive absorption of ammonia from the rumen would be expected to reduce N excretion by 15% compared with cows fed according to crude protein standards.

Amino acid supplementation is often cited as a technology with real potential to reduce N excretion. Theoretically, amino acids fed to balance the amino acid flow to the small intestine allow the animal to absorb a “perfect” profile of amino acids, precisely matched to its requirements for maintenance, growth, pregnancy, and milk yield. The benefit of this technology in monogastrics (pigs, poultry) is unquestioned, as supplemental methionine and lysine allow the amino acid requirements of the animals to be met with a reduced crude protein diet. The only difficulty lies in precisely defining the amino acid requirements of the animal.

In ruminants, however, the use of amino acid supplements is complicated by the complexity of rumen fermentation. Predicting flow of amino acids to the small intestine of ruminants is a very difficult task, given the variation in feed intake, rumen fermentation, and liquid and solid passage rates. This variation makes it quite difficult to predict the response to amino acid supplementation, and currently limits the use of amino acid technology in ruminants.

Recent research by scientists in Maryland and Pennsylvania indicates that milk urea N (MUN) concentration has real potential to help farmers identify opportunities to reduce N excretion. Milk urea N analysis was developed as a tool to monitor protein utilization by dairy cows. Urea is a small metabolic byproduct of protein utilization. When cows are overfed protein relative to their needs for growth and milk protein synthesis, the unused portion of protein is converted to urea. Urea diffuses into the milk from the cow's blood stream. With overfeeding of protein, the concentration of urea in milk increases.

Milk urea N content is a quick, accurate reflection of how much N was absorbed by the cow but not used for growth or milk protein synthesis. Recent research by the Maryland scientists indicates that MUN is also very closely linked to urinary N excretion. Thus the MUN assay is a powerful tool to tell us when the cow is wasting protein and excreting excessive nitrogen. Elevated MUN indicates an opportunity to reduce protein content of diets, maintain or improve milk yield, reduce N excretion, and, possibly, reduce feed costs.

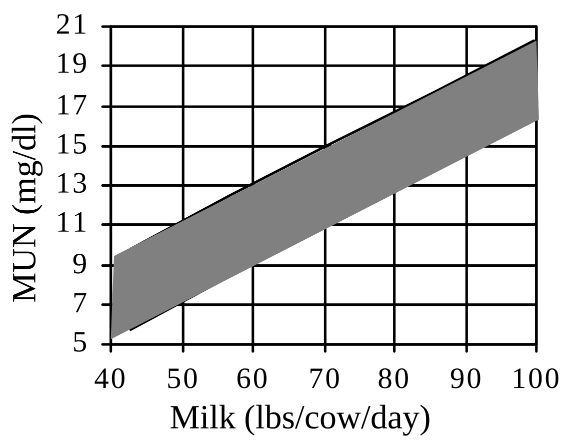

Figure 1. Target MUN values for a group of 25 Holstein cows with milk averaging 3.5% milk fat and 3.0% milk protein.

Reducing P losses through nutrition

Phosphorus is required in animal diets for bone formation and maintenance, milk secretion, building muscle tissue, energy metabolism, fatty acid transport, phospholipid synthesis, amino acid metabolism, and protein synthesis. Phosphorus is also a component of nucleic acids involved in cellular metabolism, and enzyme and buffer systems. About 70% of consumed P is excreted, but P content of manure varies significantly with diet.

Phosphorus intake is strongly correlated to P excretion, so changing dietary concentration of P has real potential to reduce P excretion. Reduced P content of manure reduces land applied P, reducing potential P runoff. Workers in Florida fed lactating dairy cows diets containing three levels of P, one below current published requirements, one roughly corresponding the current recommendations, and one about 35% greater than requirements. They demonstrated that increasing P intake increased P excretion linearly. Milk yield was not affected by P intake in this study.

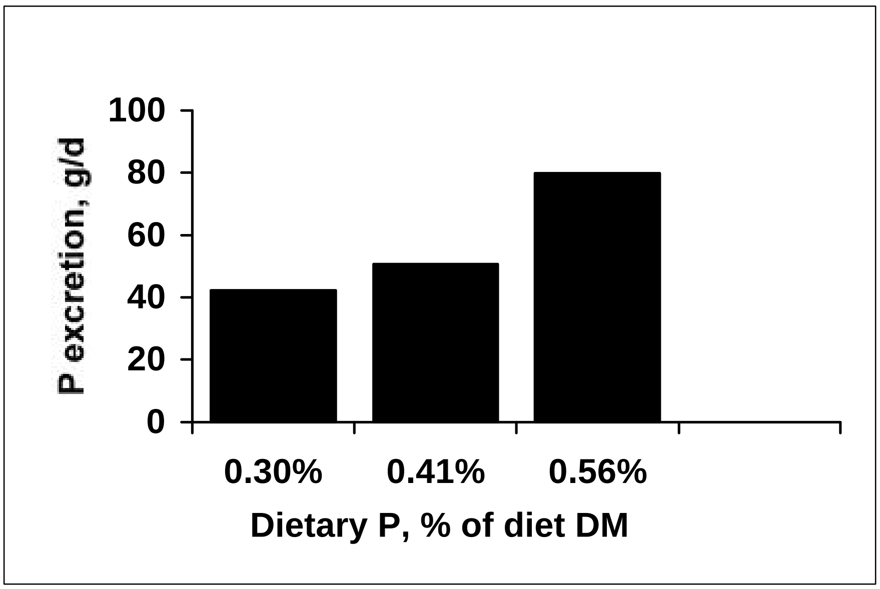

Figure 2. Effect of dietary P concentration on P excretion in lactating cows.

The current published P requirement is about .35 - .4% of diet dry matter, but the P content of rations in the field typically averages .5% of the diet or more, 25 to 40% greater than requirements. An important point is that cows require a certain quantity of phosphorus, not a specific concentration. The higher the dry matter intake, the lower the dietary P concentration needed to meet the cow's requirements. Targeting rations to a specific percent P is common practice, but often results in unintentional overfeeding.

Phosphorus is also overfed because high P diets are commonly believed to improve reproductive performance. While P deficiency has been shown to impair fertility, there is no data to suggest benefit to increased P feeding to dairy cows. In fact, one study indicates depressed milk yield when P was fed at 40% over requirements compared to cows fed at the requirement.

A recent survey of 33 Virginia dairy farms indicated that these farms were overfeeding P significantly, by an average of 45%. Average dietary P content in rations fed to these herds was .49%, but the actual P requirement of these herds averaged .34%. This overfeeding increases P excretion by 45%, and increases the farmer's feed bill by an average of more than $1,000/year. Reducing P intake to actual requirements is one "best management practice" that doesn't cost, it pays!

Reducing P losses from livestock farms is a hot topic politically. In Maryland, legislation has just passed outlawing the application of manure to soils that have very high P concentrations. The details of the regulations are not yet settled, but P-based nutrient management regulations in any form will have a significant impact on livestock farms in many areas. Reducing P intake to published requirements will save most farmers money and will help to reduce P application to land, preparing you to meet future regulations.

Land application of N and P in manure or commercial fertilizer in excess of crop requirements may impair water quality, threatening human and animal health. As an industry, we need to identify and implement techniques that will reduce the environmental impact of dairy farms while maintaining their economic viability. Fine-tuning rations to more precisely define and meet the N and P needs of the cow is an economical, effective way to reduce potential nutrient losses from dairy farms. Balancing rations for degraded and undegraded protein, reducing dietary P to current recommendations, and monitoring your herd's protein status through MUN analysis are powerful, cost-effective approaches to reduce nutrient losses from your farms and protect water quality.