Animal Agriculture and the Environment

Reducing nitrogen losses through nutrition

by Drs. Katharine Knowlton and Joe Herbein

Postdoctoral Research Associate and Associate Professor, Virginia Tech Department of Dairy Science

Nitrogen and phosphorus contamination of ground and surface water are the leading environmental issues facing livestock farmers in Virginia. Typically, efforts to reduce nutrient losses from farms have focused on manure management: handling nutrients once they accumulated 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. Recent work suggests real opportunities to reduce nutrient losses through improved nutrition and herd management. This article focuses on the opportunity farmers and their advisors have to reduce nitrogen losses from dairy farms through nutrition.

Environmental concerns associated with nitrogen include contamination of ground and surface water, and impaired air quality (ammonia). Excess nitrogen in bodies of surface water from runoff, acid rain, or resurfacing leached nitrogen causes algae populations to grow rapidly, or to “bloom”. The decomposition of the algae consumes dissolved oxygen in the water. Dissolved oxygen in water is a major factor affecting the survival and productivity of fish in surface water, and 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 and wells 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. Also, nitrogen 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. This presents a quandary: Volatilization of nitrogen from manure is attractive to help balance manure nutrient application with crop needs, but causes acid rain.

Recent work suggests real potential to reduce nitrogen losses from dairy farms (N runoff, leaching, volatilization) through nutrition. Improved efficiency of protein utilization would allow the same or increased productivity with a lower dietary protein (nitrogen) concentration, and reduce nitrogen excretion. Balancing rations for ruminally degraded and undegraded protein rather than total crude protein reduces nitrogen 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 nitrogen excretion by 15% compared with cows fed according to crude protein standards. Forage type and quality also affect nitrogen excretion through their effects on rumen fermentation. The very rapidly degraded protein in immature pasture, for instance, increases nitrogen excretion unless the pasture is properly supplemented. Research at Virginia Tech and at other universities is focusing on proper supplementation of pasture for lactating cows.

Amino acid supplementation is often cited as a technology with real potential to reduce nitrogen 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 acid to the duodenum of ruminants is a monumental task, given the variation in feed intake, rumen fermentation, and liquid and solid passage rates. This variation makes it very difficult to predict the response to amino acid supplementation, and limits the use of this technology in ruminants.

Systems such as the Cornell/Penn Net Carbohydrate and Protein System balance diets for amino acid requirements rather than just crude protein. This model is continually evolving, and may one day be a useful and practical tool on farms. Recent evaluation of the model using the provided "book values" indicated that the model does not predict nutrient requirements even as well as the current NRC model does without expensive (and often unavailable) feed analyses. More progress is needed before we are able to reliably balance dairy rations for amino acids.

In summary, there is real potential to reduce nutrient losses on dairy farms through improved herd nutritional management. More precise definition of protein requirements and less overfeeding of protein are practical techniques that significantly reduce nitrogen excretion by the dairy herd.