

Dairy farming and the Environment

Areas of Concern: Nitrogen

by Dr. Katharine Knowlton

Research Scientist, Virginia Tech Department of Dairy Science

Increasingly farmers across the country are 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. This article is the first in a series covering specific areas of concern in the relationship between dairy farming and the environment.

The first step in addressing any problem is understanding the issues involved. This article and the next few will cover specific water and air quality problems associated with dairy farming. Articles after these will focus on nutritional and herd and farm management techniques you can use to minimize the impact of your farm on the environment and improve your ability to meet environmental regulations.

Increased specialization and concentration of crop and livestock production has led to the net export of nutrients from major crop producing areas (i.e. the corn and wheat belt), and net importation of these nutrients to areas with a high concentration of livestock operations. These areas include the DelMarVa peninsula with its concentrated poultry industry, North Carolina with its hog industry, and New England, Lancaster County PA, the Chino Valley in California, the Shenandoah Valley in Virginia, and the Lake Okeechobee area in Florida all with a high concentration of dairies. These areas of increasingly intensive animal agriculture all face potential and existing problems with water quality.

Nitrogen contamination of both surface water (lakes, streams, rivers, the Chesapeake Bay) and ground water (literally, the water in the ground) is of environmental concern. Sources of nitrogen contamination include atmospheric nitrogen, fertilizer used in commercial and suburban settings, agricultural waste, both animal and crop, and human sewage.

Surface runoff and acid rain are the most common routes of nitrogen contamination of surface water. Excess nitrogen accumulation in bodies of surface water can lead to eutrophication, or excessive growth of noxious aquatic weeds. Degradation of this overgrowth of algae and water plants increases biological oxygen demand (BOD), and the depleted oxygen levels lead to fish kills. Additionally, ammonia can be directly toxic to fish.

Contamination of ground water, while less visible than surface water contamination, is also of concern. When nitrogen in manure or commercial fertilizer is applied to land in excess of crop requirements, nitrate leaching occurs. Nitrate (NO_3^-) leaches to ground water because it is a negatively charged ion in a porous medium (soil) that has an inherent negative charge. This

negatively charged soil excludes nitrate, forcing it into the liquid phase (ground water) where it leaches, contaminating ground water and wells.

Nitrate in drinking water is converted to nitrite (NO_2^-) in the human digestive tract. Nitrite can replace oxygen in hemoglobin creating a compound called methemoglobin, which is much less efficient at carrying oxygen than is hemoglobin. With increased levels of methemoglobin, oxygen levels in the blood decrease, resulting in cyanosis, or oxygen starvation. Infants are more susceptible to methemoglobinemia than adult humans for several reasons. Infants convert more of the ingested nitrate to nitrite, have hemoglobin more susceptible to oxidation, and have lower levels of the enzyme to convert methemoglobin back to hemoglobin.

Because of this health concern, a legal limit for nitrates in well water of 10 mg/l (ppm) was established in the U.S. in 1985. This level is based on human case studies indicating fatal poisoning in infants following ingestion of water with nitrate-N concentration greater than 10 ppm. The US EPA conducted a survey of drinking water in 1990 and found that 52% of the wells surveyed contained detectable nitrate, and 1.2% of those surveyed had nitrate-N concentration above the legal limit. Nitrate-N concentration was highest in rural wells, with 2.4% of those wells above the legal limit for nitrate-N. Increased nitrate-N in wells was correlated with increased sales of nitrogen fertilizer and increased market value of crops and livestock on nearby farms.

An additional concern with nitrogen contamination of drinking water is that ingestion of nitrite or nitrate-N with amines has been shown to cause cancer in several organ systems. Nitrate in drinking water has been correlated with gastric cancer risk, but direct causation is still unclear. What is well established is that nitrite is a precursor to nitrosoamines, and that these nitrosoamines are potent carcinogens. Also, nitrate poisoning can be a problem in ruminants, with symptoms including cyanosis (blue skin) around the eyes, rapid heartbeat, shortness of breath, staggering, and collapse. Reduced milk yield and aborted calves are also symptoms.

Finally, 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 50-85% 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. Additionally, ammonia reacts with acidic gases in the atmosphere to form ammonium salts which are transported across large areas and acidify soil and water. Soil deposition of ammonium salts leads to leaching of potassium, magnesium, and calcium, further disrupting plant growth. This presents a quandary: Volatilization of nitrogen from manure is attractive to help balance manure nutrient application with crop needs, but causes acid rain.

In summary, land application of nitrogen in manure or commercial fertilizer in excess of crop requirements is of environmental concern for several reasons. One point to be emphasized is that when managed appropriately, land application of manure is not in itself a risky environmental practice. The key is balancing nutrient application with soil analysis and crop requirements to minimize nutrient loss to the environment. Future articles will cover nutritional and herd management techniques to reduce nitrogen losses from dairy farms.