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# Water Quality: The Animal Component

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Good manure management practices are needed more than ever before. Intensive livestock production schemes put more animals on smaller pieces of real estate. These operations can be successful environmentally when managed correctly, but animal waste can cause degradation of water resources if it is not properly managed. Quality water is essential to maintaining not only a healthy environment, but also a healthy economy. Typically, major contaminants arise from residential, industrial, or agricultural sources. To maintain high quality fresh water it is necessary to minimize contamination of surface and ground water sources.

## North Dakota's Problems

The 1990 North Dakota Agricultural Statistics publication reported that there were 1,750,000 beef cattle, 88,000 dairy cattle, 280,000 hogs and pigs, and 186,000 sheep in the state. If we could collect 80 percent of the manure produced by the beef and dairy cattle in one day it would create a 1 foot by 1 foot line of manure that would extend 282 miles. That's a lot of manure! But, looked at another way, proper recycling of these nutrients would only require 330 acres of wheat acreage a day to utilize the phosphorus, if manure was applied in an environmentally acceptable way.

Producers of milk, meat, and fiber incorporate many management practices to obtain their end products. Animals convert forages, grain, vitamins, minerals and water to value-added products for human consumption. The major by-product of this process is manure. Managed inappropriately, manure can release phosphates and nitrates that cause water quality problems.

These two pollutants can cause algal blooms, fish kills, health hazards, increased aquatic weeds, aesthetic changes, and reduced wildlife diversity. Although both surface and ground water can be affected adversely, this circular will stress management practices to minimize surface water contamination. Keep in mind that MOST waste products are simply nutrients out of place.

Contamination of surface water is one of many concerns for agriculturalists. Key signals that indicate possible problems have already been determined. Reduced oxygen concentration in water, existence of specific bacteria not normally present in 'clean' water, and increased occurrence of algae blooms have been documented in North Dakota.

## Best Management Practices

Best management practices (BMPs) are designed for the specific purpose of controlling non-point source pollution. BMPs must be effective and practical. With the exception of very large feedlots, animal waste disposal is largely a non-point source pollution problem. No one system is "best." Every scenario has advantages and disadvantages. It is up to the land user to determine which compromises will be most effective. These trade-offs will include labor needs, cost of setup and maintenance, regulations, convenience, and technical competency of the individual available to oversee operations.



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Nutrients entering the water supply come from existing sources (native or non-improved pastures) or from imported nutrients (feed, minerals, chemicals, fertilizer). Existing nutrients come and go as organic material is recycled through the environment. Imported nutrients include fertilizers, livestock feeds and supplements, and chemicals used by humans or in agricultural practices.

Cropping systems can be managed to maximize nutrient uptake from soil. This would reduce potential contamination of the water supply and utilize the fertilizer value of manure. Conservation cropping systems are used to grow crops in combination with needed cultural and management measures to improve the soil and protect it during periods when erosion occurs. These include cover cropping and crop rotation. Such practices provide vegetative cover between crop seasons and maximize nutrient uptake into plant matter, thereby limiting possible contamination of ground water.

There are several BMPs that involve the location of animals and their waste with respect to water sources, use of waste as fertilizer, and reducing nutrient imports. Some of these BMPs are:

## *Location of waste:*

Primary goals of manure management are to utilize the value of manure nutrients as fertilizer, protect the public's health and safety, minimize degradation of air and soil, and prevent pollution of surface and ground waters.

- Store manure in elevated, well-drained places. Be sure water flows around manure piles and not through them. Simply rerouting the flow of run-off water can reduce water contamination problems.
- Grade outside lots to provide good drainage and to keep clean outside water from washing manure away. All outside water should be diverted away from manure storage areas. Drainage from lots shouldn't run into streams or creeks nor should it enter someone else's property.
- Control of flies and rodents is a must in manure management. Both of these can be nuisance problems to the farm operator and neighboring operations. Understanding the life cycle of flies will be critical to fly control. Species of fly and environmental conditions (temperature and moisture level) will have direct effects on a desirable location for stored manure. All stored manure should be hauled out before summer. This will minimize carry-over from season to season.
- Don't allow animal access to frozen creeks and waterways. Provide temporary fencing if necessary to prevent animals from depositing manure on a frozen waterway. Animals tracking through creeks often hasten soil erosion problems by destroying plant life.
- Use a pump to relocate water from a creek into a trough. This will keep animals away from running water and minimize direct deposit of manure from animals into a stream or creek. Also, keeping animals away from the waterway will maintain growth of vegetation on the banks of the waterway. This will reduce the flow of solids into the waterway.
- Maintain adequate pasture conditions. This will maximize nutrient uptake by pasture plants and reduce nutrient flow into waterways. Overstocking pasture is a sure way to damage water quality. Overstocking damages plants, which reduces nutrient uptake and increases risk of erosion.
- Don't store manure directly near or uphill from water wells. Storage of manure by the well or near the opening of a well will increase the possibility of nutrients and bacteria contaminating the well.
- Keep animals away from piled manure. Animals housed on manure will pack manure and spread it over a greater surface area. This increases the ground-manure pile surface contact and may increase the probability of water contamination. Excluding animals from manure piles is the law for dairy producers in the United States and is good advice for producers of other livestock. There may be greater spread and occurrence of disease if animals are allowed access to piled manure.

It is important to minimize health risk to the animals and the humans involved in animal care. Detailed information about storage systems is available in the Livestock Waste Management Facilities Handbook published by the Midwest Plan Service, available through NDSU Extension Agricultural Engineering.

Ideally, manure storage systems are designed as livestock housing and handling facilities are designed. Unfortunately, what usually happens is that animals are added to an operation and no accommodations are made for manure storage. Safety of storage systems depends on the type of animals, type of system, load on the system, and operating personnel.

Animal type and facility design can dictate, in part, what the storage system will be. Below ground storage systems, or pits, are more hazardous to humans and animals than above ground systems. The most dangerous systems are pits within buildings or directly beneath livestock pens. The danger is from breathing gases (methane, ammonia, hydrogen sulfide and other volatiles). Odors can also be a nuisance to neighboring farms. The most critical times are when manure is being agitated or pumped out and after emptying. This is when most gases are produced. At other times, little gas is produced, and natural air ventilation from fans (if installed correctly) usually prevents hazardous buildup of gases. Systems that are covered by lids, caps or slotted floors are more hazardous than uncovered systems.

With open storage and above ground tanks, oxygen depletion and toxic and explosive gas buildup are less likely. The primary danger associated with such systems is drowning.

Maximum safe gas concentrations have been established. These threshold limit values are determined for an eight hour exposure for humans. Safe gas levels for animals have not been established but are thought to be somewhat lower than the eight hour human exposure values as animals are exposed for continuous periods. The values for humans are expressed in parts per million (ppm) for hydrogen sulfide (10), carbon dioxide (5,000 or 0.50 percent), ammonia (25), and methane (1,000 or 0.10 percent).

Hydrogen sulfide is the most toxic gas associated with liquid manure storage. Concentrations of hydrogen sulfide greater than 0.1 percent can cause immediate unconsciousness and death through respiratory paralysis. Hydrogen sulfide smells like rotten eggs. It causes eye and nose irritation (100 ppm), headaches, and dizziness (200 ppm), nausea, excitement, insomnia (500 ppm) unconsciousness and death (1,000 ppm). The sense of smell may be destroyed at toxic concentrations.

Animal response to increased concentration of carbon dioxide depends on the species. Hogs are most susceptible to carbon dioxide. The average concentration in a normally ventilated hog confinement unit may be 0.06 percent (about twice that of normal atmospheric air). Without ventilation, the level can rise to over 0.4 percent in six hours. Most species of livestock show increased breathing (30,000 ppm) with drowsiness and headaches (40,000 ppm).

Ammonia can be a throat (400 ppm) or eye irritant (700 ppm), cause coughing and frothing (1,700 ppm) or asphyxiating (3,000 ppm).

Methane is lighter than air and tends to rise. It will accumulate near the top of structures in areas of stagnant air. In such areas it can cause asphyxiation, but explosions are a more serious concern.

### Manure as fertilizer:

Apply fertilizers as recommended. The old theory of "if a little is good more is better" does not apply to fertilizer. Excess application of nutrients can, and often does, contaminate surface or ground water. Also, crop production can be hindered by improper concentrations of needed nutrients.

Use of commercial fertilizer may be practiced more often than the spreading of manure. In some instances this occurs because the product cost and time associated with use of commercial fertilizer is less than that associated with collection, storage, and spreading of manure. However, merely looking at the cost of the nutrients available in fertilizer versus those available from manure provides an incomplete picture. The complete picture must incorporate the alternative of not using the manure as fertilizer with the appropriate mode of manure collection and disposal.

- In many situations manure is an inexpensive fertilizer for nearby cropped fields. Manure should be spread and incorporated into soil.
- The total amount of manure added to a given field should be based on results from testing the nutrient content of both the manure and the soil. Soil should be tested every few years. Generally, less manure is needed per acre after the first year of application. This is because there is a rapidly available portion of nutrients in the manure that is used in the first year and a more slowly available portion of nutrients used in additional years. The addition of organic matter to the soil from manure is an added bonus over commercial fertilizer. You should always know which nutrients are lacking in your soil and apply no more fertilizer than is needed to make up deficiencies. Applying excess manure is not cost effective, can reduce crop production, and increases potential for water pollution. Continued application of manure at excessive loading rates may eventually saturate the land with salts. This depends on soil type, weather conditions, and cropping practices.
- Work manure into the ground to reduce loss of ammonia (the volatile form of nitrogen) and reduce surface water contamination if rain occurs after manure application. Merely spreading manure without incorporation leaves it exposed to surface runoff and thus a threat to water quality. Loss of ammonia nitrogen will also be greater when manure is not incorporated into soil. As much as 80 percent of manure nitrogen can be lost, depending on storage and handling techniques. If much of the nitrogen is lost in the form of ammonia, additional manure or another source of nitrogen (commercial fertilizer) will need to be used to meet nitrogen needs. This may cause an excessive amount of minerals to be deposited.

### Reduce imported nutrients:

Traditionally, individuals have evaluated the animal component of water quality simply. Animals eat. Animals produce manure. The end thought is keep the manure (nutrients) out of the water. It is evident that the question of manipulation of manure quantity and nutrient concentrations has been overlooked. This is the new direction for producers and researchers to evaluate. Managing nutrient intake can minimize nutrient excretion by animals.

- Feed balanced diets to livestock. Animal diets are often overlooked as key contributors to surface water contamination. In fact, many operations import more nitrogen and phosphorus as feedstuffs (grain and mineral supplements) than in any other form (fertilizer, etc) (Table 2).

Formulating a balanced diet will maximize nutrient use by animals and optimize feed costs. If an excess of energy is fed (protein is inadequate), energy will be wasted. In fact, animals will tend to put on body condition instead of growing. Minerals, particularly calcium and phosphorus, should be included in the diet when possible and not fed free choice. It is best to force feed these minerals, as beef and dairy animals do not regulate intake of calcium or phosphorus based on individual needs.

## Current Laws

Rules and regulations for control of pollution from livestock operations have existed in North Dakota since the early 1970s. The North Dakota State Department of Health (NDSDH) has guidelines for the control of pollution from certain livestock enterprises. The rules were enacted to prevent degradation of water quality in North Dakota by requiring water pollution control facilities for certain livestock enterprises.

It is the responsibility of the livestock operator to comply with requirements. The state law defines "concentrated feeding" or feedlot as any livestock feeding, handling or holding operation or feed yard where animals are concentrated. It further states that this area is not normally used for pasture or for growing crops and is where animal waste accumulates. An alternative definition is where space per animal unit is less than 600 square feet.

700 Animal units

The following practices apply to all livestock operations and can be found in statutory provisions of Sections 61-01-13 and 61-28-06, North Dakota Century Code:

1) Livestock cannot be fed on the ice cover over streams or lakes in the winter.
2) Livestock cannot be fed within 60 feet from the top of the bank of a lake or stream.

Waste handling plans must be approved by the NDSDH under certain circumstances. If the NDSDH determines an operation is causing or is likely to cause pollution of waters, the operation will be notified that corrections must be made. Another group requiring approval of waste handling plans is livestock operations where the number of animals being fed, handled, or held at any one time is equal to or exceeds 200 animal units. Lastly, concentrated operations located in a flood plain with more than 100 animal units and operations where the distance to the nearest point to waters of the state is less than two (2) feet per animal unit fed, handled, or held in the operation at any one time must receive approval.

Operators of proposed facilities must submit an application for approval for waste handling operations or discharge of wastes to the NDSDH. Departmental approval is required prior to construction of new facilities. The NDSDH may elect to inspect the site and operations. Approvals are valid as long as the operation is not materially changed or the state's water quality standards are not violated but shall be subject to annual review.

Building of water retention facilities is costly. It is accepted that producers will be required to contain the runoff from a 25 year-24 hour storm. This ranges from 3 (northwest) to 4 inches (southeast) of rainfall.

# Conclusion

Maintaining quality water is a critical management strategy facing all livestock producers. It is important to evaluate the entire operation. There is no one system that will be 'best' for all producers. Every situation is different and has its own circumstances. It is the operator's responsibility to determine which combination of practices will be useful to optimize resources and to maintain water quality.

Waste should be collected and stored to minimize water contamination. Typically, water pollution problems associated with livestock enterprises are drainage problems. Proper planning and placement of manure piles, routing of rain and lot water around manure piles, and controlling snow melt runoff with proper location of shelter belts or shallow ditches are the first steps to minimize surface water pollution.

Nutrients in manure can be used as fertilizer. There are costs associated with disposal of manure, but there are also costs associated with purchase and incorporation of fertilizer. Purchasing fertilizer may be easier than using manure.

How then will manure be disposed of? What are economically acceptable ways to minimize nutrient concentration in manure, dispose of manure, supply nutrients for field crops, and maintain water quality?

Assistance may be available to producers from several organizations and agencies, within the limits of their staff and budget including: 1. division of water supply and pollution control (NDSDH); 2. district health unit offices; NDSU Extension Service agricultural engineer; 3. local NDSU Extension Service county agents; 4. Soil Conservation Service; 5. Soil Conservation Districts.

**Table 1. Fresh manure production and characteristics per 1,000 pounds of live animal weight per day.**

| Measure | Units | Beef | Dairy | Horse | Swine | Sheep | Duck |
|---|---|---|---|---|---|---|---|
| Total manure | lb | 58 | 86 | 51 | 84 | 40 | 110 |
| Urine | lb | 18 | 26 | 10 | 39 | 15 | — |
| Density | lb/ft$^3$ | 63 | 62 | 63 | 62 | 64 | — |
| Total solids | lb | 8.5 | 12 | 15 | 11 | 17 | 32 |
| Volatile solids | lb | 7.2 | 10 | 10 | 8.5 | 9.2 | 19 |
| $BOD_5$ | lb | 1.6 | 1.6 | 1.7 | 3.1 | 1.2 | 4.5 |
| COD | lb | 7.8 | 11 | — | 8.4 | 11 | 27 |
| Total N | lb | .34 | .45 | .3 | .52 | .42 | 1.5 |
| $NH_3$-N | lb | .086 | .079 | — | .29 | — | — |
| Total P | lb | .092 | .094 | .071 | .18 | .087 | .54 |
| Ortho P | lb | .030 | .061 | .019 | .12 | .032 | .25 |

ASAE D 384.1. 1990. American Society of Agricultural Engineers. ASAE Standards, 19.

**Table 2. Nitrogen, phosphorus and potassium content of one ton (as fed) of feed or feed supplement.**

| Ingredient | % DM | N | P | K |
|---|---|---|---|---|
| Barley | 89 | 41.30 | 6.76 | 8.37 |
| Corn | 89 | 28.48 | 5.16 | 6.59 |
| Wheat | 89 | 45.57 | 7.48 | 7.48 |
| Oats | 89 | 37.88 | 6.76 | 7.83 |
| Brome Hay | 89 | 28.48 | 6.23 | 41.30 |
| Alfalfa (17 %) | 89 | 48.42 | 3.92 | 44.86 |
| Limestone | 95 | --- | 722.00 | --- |
| Dicalcium phosphate | 95 | --- | 418.00 | 351.50 |
| Bone meal | 93 | --- | 520.80 | 260.40 |

% DM — percent dry matter
N, P, K — elemental forms of nitrogen, phosphorus, and potassium

Additional references:
MWPS-18 Livestock waste facilities handbook
Water Quality: The Rangeland Component
AS 956 Animal Waste Management
North Dakota rules and regulations for the control of pollution from certain livestock enterprises regulations no. 61-28

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