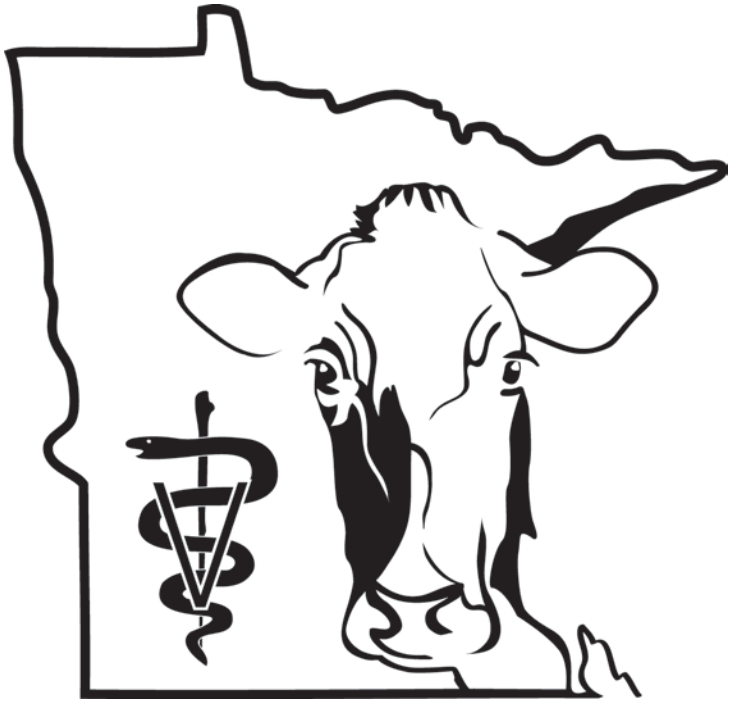
THIS ARTICLE IS SPONSORED BY THE
MINNESOTA DAIRY HEALTH CONFERENCE.

UNIVERSITY OF MINNESOTA

College of Veterinary Medicine

VETERINARY CONTINUING EDUCATION



ST. PAUL, MINNESOTA
UNITED STATES OF MINNESOTA

COWS PRODUCE MORE THAN MILK!

David Schmidt, Assistant Extension Engineer
Department of Biosystems and Agricultural Engineering

INTRODUCTION

Dairy cows produce more than milk!! A significant by-product from all dairy operations is manure. Unfortunately, this byproduct is seldom viewed as an asset and is often considered a liability. Handling of this by-product costs money; however, some of these costs can be recovered with a properly designed and operated manure system. A properly designed and operated manure system will also reduce the potential for this manure to negatively impact the environment. All livestock producers are being required by neighbors, concerned citizens, environmental groups, and regulators to reduce the impact of manure on the environment. Proper manure handling requires an understanding of manure characteristics, potential pollution problems, basic manure system design concepts, and current regulations.

MANURE PRODUCTION AND CHARACTERISTICS

In order to understand the potential environmental problems with manure or attempt to manage manure to avoid environmental problems, it is important to understand some of the physical and chemical characteristics of manure (Table 1). The information presented in Table 1 represents average "as excreted" values for dairy manure. The actual nutrient content and physical characteristics of manure at any point in the manure handling system are dependent on management factors and the design of the collection and storage system.

Table 1. Dairy Manure Production and Characteristics. (ASAE Standards Manual 1996)

All values per 1000 lb live weight dairy cow

Production	86 lb/day or 1.39 ft^3/day or 10.4 gal/day
Moisture	87.3%
Density	62 lb/ft^3
Total solids	12.0 lb/day
Volatile solids	10.0 lb/day
Biological Oxygen Demand	1.6 lb/day
pH	7.0
Total Nitrogen	0.45 lb/day
Total Phosphorus	0.094 lb/day
Total Potassium	0.29 lb/day

Nutrient losses, primarily nitrogen, occur through volatilization and microbial decomposition of the organic fraction of the material. Nitrogen loss can be from 20-80%, depending on the type of manure handling system. These losses occur in manure collection, storage, and land application (Table 2). Total phosphorus and potassium losses are approximately 5-10%. Moisture content will vary significantly depending on the bedding material and type of collection system. Obviously, the moisture content of manure from a flush system will be much greater than the "as excreted" values and the moisture content of a bedded pack system will be much less than the "as excreted" values.

Table 2. Nitrogen loss in manure handling. (Mid West Plan Service Publication MWPS -18)

	N - loss
Solid Storage	
Daily Scrape and Haul	15-35%
Manure Pack	20-40%
Open lot	40-60%
Liquid Storage	
Beneath barn pit	15-35%
Above ground storage	10-30%
Earthen storage	20-40%
Lagoon	70-90%
Land Application (total loss)	
Broadcast no incorporation	35%
Injection	5-10%

ENVIRONMENTAL CONCERNS

Nutrients

Manure can be a significant benefit to the dairy operation if the nutrients from the manure are used for crop production. However, this is not always the case. Manure nutrients can leach into ground water or be transported by erosion or runoff to surface waters. Potential for this movement of manure nutrients is a concern during all phases of manure handling. Nitrate-nitrogen can leach from earthen manure storages or from fields where manure has been applied. Phosphorus movement can be a factor when there is runoff from open lots, runoff from manure stock piles, or runoff or erosion from fields where manure has been applied. Although the concentration of nitrogen and phosphorus in the manure is low, these concentrations can impact water quality. High nitrate concentrations in groundwater can cause a condition in infants known as methemoglobinemia, commonly known as "blue baby syndrome." Methemoglobinemia results when nitrates in drinking water disrupt the oxygen transport capabilities of the blood.

Phosphorus in surface waters will cause excessive growth of aquatic plants. This excessive growth will increase the rate of eutrophication for those affected water bodies.

To prevent the movement of manure nutrients manure systems must be designed and managed properly. Manure storages must be designed to prevent the leaching of nutrients through the use of a clay, concrete or synthetic liner. Manure application must be based on crop nutrient requirements and on fields where erosion and runoff is not a problem. Manure application guidelines are available from the Minnesota Department of Agriculture and the Minnesota Pollution Control Agency.

Organic Matter

Another cause for environmental concern is when the organic fraction of manure enters surface waters. This added organic matter will result in increased microbial activity. Typically, this increase in microbial activity will reduce or deplete the dissolved oxygen (DO) in the water body. This reduced oxygen supply could make the water uninhabitable for fish or some forms of aquatic vegetation. Several fish kills have been reported as a result of manure spills. These fish kills are a result of decreased oxygen supply in the water body due to the organic loading from the manure spill.

Pathogens

There is a renewed interest in the survival and transmission of pathogenic viruses, bacteria, fungi and parasites in manure. Research indicates that most pathogens found in manure are not a threat to human health. Even so, most of these organisms typically do not survive a 30-day storage time or land application. Although there have been few reported links between animal manure and human health (due to pathogens), more research is probably needed in this area due to the recent increases in concentrations of animals and animal manure.

Air Quality

Gases emitted from livestock facilities have recently received more attention than manure-related water quality concerns. Although most problems have been associated with swine facilities, any new or expanding facility is being viewed as a potential hazard to air quality. Nearly 200 gaseous compounds are emitted during the decomposition of manure. Primary compounds such as hydrogen sulfide, ammonia, carbon dioxide, and methane are easily identified. Other gases are present in amounts at or below detection levels. However, many of these lesser gases, along with hydrogen sulfide, are extremely odorous. These odorous gases are typically viewed as a nuisance but in some cases may be considered a health risk. Typically, concentrations that could cause health problems are only found occasionally inside animal facilities. For example, toxic hydrogen sulfide concentrations have been reported inside deep-pitted facilities during manure agitation and pumping. Therefore, extreme caution must be taken during agitation and pumping from these

facilities. No persons, for any reason, should enter a building during the agitation process and animals should be removed if at all possible.

Very low hydrogen sulfide concentrations are being viewed by the Minnesota Department of Health (MDH) as a potential health risk.. Some evidence suggests that concentrations as low as 30 parts per billion over an extended period of time may be a health risk in certain human populations. As of yet, the actual "Health Risk Value" for hydrogen sulfide has not yet been determined by the MDH. Values of hydrogen sulfide well above 30 ppb have been reported in odor plumes from swine facilities in Minnesota. The Minnesota Pollution Control Agency is currently requiring hydrogen sulfide monitoring in some feedlot permits.

The production of these odorous gases is unpredictable. Variations in manure handling systems seem to be the most important factor for controlling odor, however, other factors such as type of animal, animal diet, manure management practices, and water supply may also contribute to reducing odors. Current research efforts at the University of Minnesota and other Universities are focusing on the measurement and control of these gases.

MANURE HANDLING SYSTEM DESIGN

Manure systems designs are based on several factors. Many of these factors are constant yet others are dependent on site specific conditions. Therefore, there is not one "right" design that will fit all facilities. Each operation is unique; therefore, a manure system must be designed based on these unique factors. Primarily, a manure system is designed to preserve herd health and protect the environment. This means that a manure system is designed to efficiently move the manure away from the animals and to some end use, typically land application without allowing the manure to enter surface water, ground water, or contaminate the air. Several designs meet these requirements. Secondary considerations include producer preferences, size of operation, site location, availability of labor and management, geography and topography of the site, existing manure system, land availability for manure application, economics, government regulations, and a variety of other factors.

The following outline is helpful when choosing a manure system.

1. **Choose a bedding system.** The choice of bedding systems will reduce the number of options for manure handling. For example, sand bedding cannot be used with an earthen storage basin or in a deep pitted barn. Mattresses, sand, straw, or wood shavings are all possible bedding options. Choice of bedding must be based on cow health, bedding availability, and personal preference.
2. **Get information on current state, county, or township regulations.** Regulations and zoning requirements differ across the state. These regulations may limit the type of manure storage facility that can be

permitted. These regulations may also eliminate the option of winter spreading or open storages.

3. **Evaluate land availability for manure application.** This evaluation must include both how much land is available and when it is available. Mini-pits and daily haul systems require land to spread manure on throughout the year.
4. **Evaluate labor requirements.** For example, labor requirements for a tractor scrape system are different than that of a fully slotted floor. With a slotted floor deep pit barn labor is required only at pumpout. With a tractor scrape system labor is required for a short time each milking.
5. **Evaluate the economics on a long term basis.** Capital investment is not the only cost that needs to be included. A partial budget must also include labor costs, herd health, milk production, bedding costs, cost for operation and maintenance and credits for manure nutrients.

REGULATIONS

Both state and local regulations must be considered for any livestock facility. Local regulations can and often are more restrictive than state regulations. Many local regulations have recently been adopted or are currently being revised. Information on local regulations can be obtained by contacting local officials.

The state of Minnesota is also in the process of revising its feedlot rules. The state feedlot program is run by the Minnesota Pollution Control Agency (MPCA) Feedlot Division. Current regulations require livestock facilities of over 50 animal units (see Table 3), or units of any size that have a pollution potential, to complete a feedlot permit application whenever any of the following conditions occur:

- A new feedlot is constructed
- A feedlot is expanded or modified
- A change in ownership takes place
- An existing feedlot is restocked after being abandoned for more than five years
- An investigation of a complaint reveals there is a pollution problem
- Any facility over 1000 animal units. (Required to obtain a National Pollution Discharge Elimination System (NPDES) permit)

State feedlot permits for livestock facilities with less than 300 animal units and not posing a pollution potential, can be administer by those Minnesota counties with designated authority. Currently 45 counties have this authority.

Table 3. Animal Unit Conversions
Measured by maximum feedlot capacity. If not listed, the number of animal units shall be defined as the average weight of the animal divided by 1000 lbs.

Type of Animal	Animal Units
one mature dairy cow (1400 lbs)	1.4
one slaughter steer (1000 lbs)	1.0
one horse	1.0
one swine over 55 lbs	0.4
one swine under 55 lbs	0.05
one duck	0.2
one sheep	0.1
one turkey	0.018
one chicken	0.01

Feedlot permit applications for less than 1000 animal units typically consist of the following information:

- Number and type of livestock.
- A sketch of the size and location of barns, lots, and manure storage facilities. This sketch must also show distances from barns, open lots, and manure storage areas to surface water; tile inlets; drainage channels; sinkholes; existing and abandoned wells; etc.
- A description of the manure handling and storage system.
- A soils map of the feedlot.
- An ASCS aerial photograph of the feedlot sites and manure spreading areas.
- A soil boring report for all below ground manure storage structures
- A plan prepared by a registered professional engineer for all earthen manure storage structures and any manure storage structures with a capacity of over 500,000 gallons.

A review of permit applications with less than 1000 animal units will result in either a:

- **Certificate of Compliance**—issued if the facility does not pose a pollution potential and manure is used as a domestic fertilizer
- **Interim Permit**—issued when a pollution potential hazard exists but will be corrected within 10 months of the date of permit issuance. When all corrective measures are in place a Certificate of Compliance is issued.
- **Five Year Permit**—These permits are used when technical considerations or financial hardship prevent correction of the pollution problem within 10 months. A timetable outlining steps to be taken will be included with

each five-year permit. Very few of these permits have been issued to date.

Facilities with more than 1000 animal units or those deemed to be a potential pollution problem are required to have a National Pollution Discharge Elimination System (NPDES) permit. This permit is a federal permit that is administered by the MPCA Feedlot Division. The NPDES permit application process is currently being reviewed by the MPCA.

Rule Revision

The Minnesota Pollution Control Agency is currently going through a rule revision process. New rules will probably go into effect sometime in 1998. Most of the proposed rule changes are issues that are currently being addressed in the existing permitting process. Rule revisions will include changes in design and construction standards for manure storage basins and lagoons, changes in land application requirements including manure testing and record keeping, and a change in the application and permitting process.

More information on manure handling systems or feedlot regulations is available in the following publications or can be obtained by contacting the following individuals.

Publications/Information

Fertilizing Cropland with Dairy Manure, #FO-5880-S, available through the Minnestoa Extension Service Distribution Center.

Livestock Waste Facilities Handbook, MWPS #18, available through the Departmentof Biosystems and Agricultural Engineering Department, University of Minnesota.

Running Your Feedlot, available through the Minnesota Pollution Control Agency

Manure web site <http:// www.bae.umn.edu/extens/manure/manure.html>

People

David Schmidt Assistant Extension Engineer—Manure Management Systems
Department of Biosystems and Agricultural Engineering
1390 Eckles Avenue
St. Paul, Minnesota 55108
612-625-4262

Kevin Janni, Ph.D., Extension Engineer,
Department of Biosystems and Agricultural Engineering
1390 Eckles Avenue
St. Paul, Minnesota 55108
612-625-3108

Minnesota Pollution Control Agency
520 Lafayette Road North
St. Paul, Minnesota 55155
1-800-627-3529