Chapter 2.
MANURE – THE BASICS

This chapter explores:

- physical and biological properties of solid and liquid manure
- chemical properties of manure odour and gases
- contamination risks from manure
- manure management as a system

Understanding the physical, biological and chemical properties of manure will help you manage manure safely and more effectively. Manure provides the same nutrients for crop production as commercial fertilizers. The challenge with manure is that the forms and ratio of the nutrients are not easy to change, nor easy to match to crop requirements. Over-application of manure can lead to problems such as contamination of water sources with nutrients and pathogens (disease-causing organisms), emission of odours and greenhouse gases, nutrient loading in the soil leading to crop lodging, and salt accumulation resulting in poor yields.

2.1 PHYSICAL PROPERTIES

Livestock manure has a variable composition. In other words, it has solid and liquid portions as well as organic and inorganic components. The composition of manure will vary with livestock type, age, size, nutrition, housing and bedding, as well as the nature and amount of materials (such as bedding and wastewater) added to it.

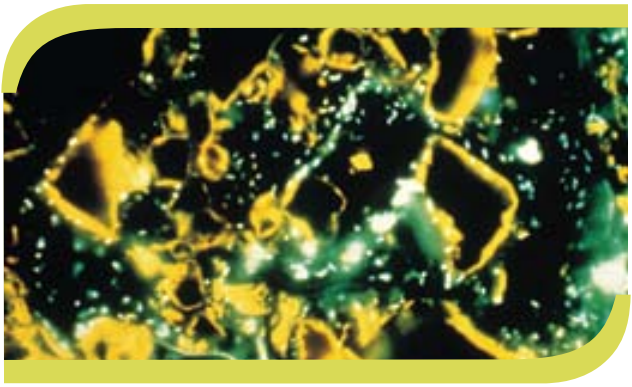
Table 2.1 Manure Components and Their Composition

Manure Component	Possible Composition
Feces	• undigested feed • other bodily wastes • pathogens • pharmaceuticals • organic forms of nutrients and organic acids • inorganic forms of nutrients and salts
Urine	• water • acids and salts • nutrients (e.g. nitrates)
Bedding	• straw, wood fibre • wasted solid feed
Water	• drinking water • leaking or spilled water • eavestroughs, precipitation, snowmelt
Washwater and Runoff	• facility washwater • milking parlour washwater • runoff from yards, stored feed and manure

ALL AGRICULTURAL OPERATORS IN ALBERTA must manage nutrients in accordance with the standards in the *Agricultural Operation Practices Act* (AOPA). For more details, talk to Alberta Agriculture and Rural Development's Confined Feeding Operation Extension Specialists or Natural Resources Conservation Board (NRCB) staff.

2.2 BIOLOGICAL PROPERTIES

Manure is made up of animal wastes, bedding, wastewaters and runoff. It is an ecosystem with all the necessities for biological habitat – namely space, cover, food and water. This can be a good thing, as biological organisms in healthy manure environments rapidly convert manure to soil organic matter and plant-available nutrients. But manure environments can also house pathogenic microbes and unwanted pests such as rodents.



Soil bacteria transform manure nutrients, making them useable by other soil life forms, such as protozoa, which in turn release inorganic nitrogen forms such as ammonium.

Table 2.2 Life Forms in Manure that Promote Decomposition

Soil Organism Group	Type of Organism	Function
Decomposers	Bacteria Fungi	• Transform manure into materials that can be used by other life forms (e.g. shredded straw into humus) • Retain (immobilize) nutrients in their tissue • Some are pathogens
Bacteria-Feeders	Protozoa Nematodes	• Release inorganic nutrients (e.g. ammonium, NH_4^+) • Destroy some pathogens
Fungus-Feeders	Nematodes Insects	• Release inorganic nutrients (e.g. NH_4^+) • Destroy some pathogens
Shredders	Earthworms Insects (e.g. springtails, dung beetles) Arthropods (e.g. centipedes, millipedes, pillbugs)	• Shred bedding and waste feed into finer-sized materials • Provide habitat and food for decomposers • Accelerate decomposition rate
Larger Predators	Large insects Rodents Birds	• Control populations of other organisms in manure • Aerate manure by burrowing

2.3 CHEMICAL PROPERTIES OF ODOURS AND GASES

The human nose is capable of detecting a broad range of odorous compounds – many at extremely low concentrations. Researchers have identified more than 165 odourless and odour-producing compounds that can originate from manure. It's this wide range and mix of compounds combined with our keen ability to detect odours that result in the variety of manure smells we experience.

Some of the more common compounds in manure gases are described in Table 2.3.

Table 2.3 Common Chemical Compounds in Manure Air Emissions

Compound	Description
Carbon Dioxide	• odourless • generated by microbial activity (anaerobic* and aerobic*)
Methane	• odourless • generated by anaerobic activity
Ammonia	• sharp, pungent, irritating odour, only mildly toxic • generated by anaerobic and aerobic activity • water-soluble and less dense than air • readily disperses in open environment, resulting in it being more of an odour concern within barns than during land application
Hydrogen Sulphide and Related Sulphur-Containing Compounds	• hydrogen sulphide gas has a powerful rotten-egg fragrance • produced during anaerobic decomposition of manure • water-soluble and heavier than air • humans can readily detect very low concentrations of H_2S, but not high concentrations • hydrogen sulphide can be very toxic if allowed to accumulate in enclosed spaces
Volatile Organic Acids	• wide variety of types and characteristics • mostly produced under anaerobic conditions • important contributors to manure odour
Phenolics	• highly odorous compounds • found in raw manure and increase under anaerobic conditions
Nitrous Oxide	• produced mainly by nitrification and denitrification of organic compounds that are present in manure • colourless and nonflammable gas • sweet and sometimes pleasant odour • known as laughing gas

* anaerobic means oxygen deficient; aerobic means oxygen rich

The amount and type of gases produced will depend on the type of manure and the way it's handled. Aerobic conditions will generate gases such as carbon dioxide and nitrous oxide. Anaerobic conditions (liquid manure storages, centre of solid manure piles) can generate such gases as hydrogen sulphide, ammonia and methane.

Some gases are often trapped within the bulk of manure until the storage is disturbed for spreading. That's why the smell is much worse at spreading time.

2.4 CONTAMINANTS FROM MANURE

Manure has the potential to cause contamination of water, air and soil. Like various other types of pollution, manure contamination can come from either point or non-point sources. Point sources are concentrated in one spot, for example, manure piles. Non-point sources are spread out over an area, for example, manure applied to fields.

A nutrient management plan is an excellent tool to minimize the environmental risks listed in Table 2.4.

Manure odour is strongest during land application. For the most part, odour-causing gases are trapped in stored manure.

Table 2.4 Contamination Risks from Manure

Resource	Key Potential Contaminants from Manure
Air	• Ammonia (NH_3) gases volatized from manure cause odours. • Nitrogen gases (N_2, N_2O) from denitrification; nitrous oxide (N_2O) is a greenhouse gas. • Methane (CH_4) from decomposing manure in barns and in storage is a greenhouse gas. • Sulphide gases are foul-smelling.
Surface Water and Aquatic Habitats	• Phosphates in solution or soil-attached in runoff can cause excessive algae blooms in surface water bodies. • Ammonia (NH_3) in manure runoff is toxic to fish and other aquatic organisms. • Nitrates in solution in manure runoff can cause excessive algae blooms in surface waters. • Bacteria and pathogens from stored and applied manure can reduce quality and safety of surface waters. • Organic matter from manure creates in-water habitat for bacteria and pathogens.
Groundwater	• Nitrates in solution can leach into groundwater, making it unsuitable as drinking water for humans, livestock watering or cleaning facilities. • Bacteria and pathogens can contaminate groundwater where water wells are improperly located, constructed, sealed, or maintained.
Soil	• Excessive soil nutrient levels can negatively impact crop growth and production. • Excessive soil nitrogen levels can lead to crop lodging. • Excessive soil phosphorus (P) levels increase the potential for total and dissolved P loss from the soil. • Salt accumulation, from repeated manure application, can result in poor crop yields and can even alter which crops will grow.

AMMONIA LOSSES CALCULATORS

The Ammonia Losses from Liquid Manure Applications Calculator and the Ammonia Losses from Livestock Buildings and Storage Calculator are simple tools for producers to use to perform a quick ammonia loss calculation for their operation. These calculators can determine how much nitrogen is not being utilized and also the cost associated with those losses. The estimation of those ammonia losses is beneficial in assessing ammonia conservation techniques and improving nutrient management recommendations. These calculators are available at www.agriculture.alberta.ca.

2.5 MANURE MANAGEMENT AS A SYSTEM

Manure management is a system. The scope of the system is strongly influenced by the type of livestock operation, the facilities, local site conditions and management practices. Some of these influences are given and not likely to change – such as the type of operation, soil type and proximity to environmentally sensitive areas. However, facilities and management practices can be changed and improved to meet both business and environmental goals.

The components of a "systems approach" to manure management are described below. Each component of the system is interactive – a planned change will impact other components of the system and thus the system itself.

Manure Management System Components

1. ***Livestock Management:*** production system, facilities, nutrition and feeding, bedding, and sanitation
2. ***Manure Storage and Handling:*** facility siting, site investigations, manure and other waste collection, transfer, storage and handling systems, and treatment alternatives
3. ***Surface Water Management of Facility:*** runon and runoff control, wastewater management
4. ***Nutrient Management Planning:*** accounting for all nutrient sources, testing levels in farm operation, assessing environmental risks and limitations, selecting nutrient sources, scheduling applications, calibrating application equipment and monitoring impact
5. ***Land Application:*** BMPs protecting soil, air and water and reducing nutrient loss, including cropping and tillage practices