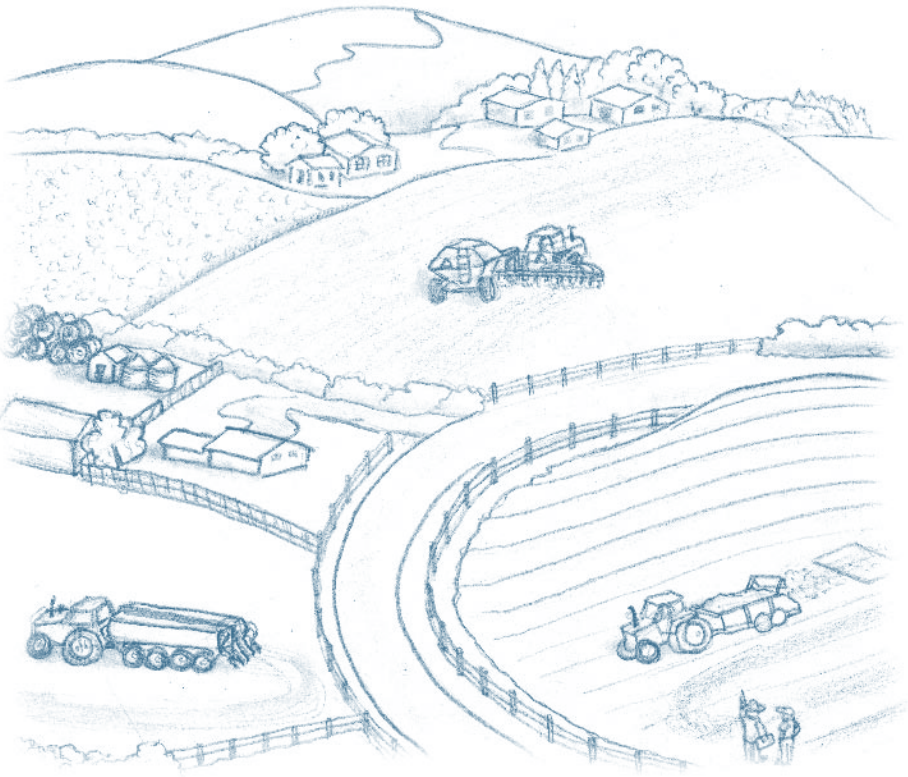
Chapter 2.3

Manure and Fertilizer as Sources of Nutrients and Potential Environmental Hazards



learning objectives

- Describe the advantages and disadvantages of fertilizer and manure as sources of nutrients for crop production.
- Summarize the risks of improper manure and fertilizer management for soil, water and air quality.

Important Terms

Table 2.3.1 Key Terms and Definitions

Term	Definition
Crop Available or Available Nutrient	A nutrient in a chemical form accessible to plant roots or compounds likely to be converted to such forms during the growing season.
Inorganic Nutrients	Nutrients that are not bound to organic carbon. These nutrients can be readily absorbed and used by plants.
Organic Nutrients	A form of nutrient that is bound to organic carbon and cannot be readily absorbed and used by a plant. Organic nutrients require a physical or chemical conversion to an inorganic form prior to use.
Soil Organic Matter	Consists of living or dead plant material, organisms, products derived from microbial and animal metabolism and stabilized complex organic material called humus. As organic matter breaks down (mineralized) nutrients are released in a form that plants can use.
Pore Space	This is the 'space' between soil particles or the total space not occupied by soil particles in a bulk volume of soil.

Manure and fertilizers are important sources of nutrients for crop production in Alberta. However, improper management can negatively impact environmental quality and human health. One of the primary reasons for developing a NMP is to maximize the benefits of manure and fertilizer application, while minimizing environmental risk.

Manure and Fertilizer as Sources of Nutrients

Fertilizers and manure are important sources of nutrients for crop production. To maximize the benefits of both, it is important to recognize how they differ.

Fertilizer

Using commercial fertilizers is less complicated than using manure for several reasons:

- The nutrient content of fertilizers is standardized and consistent. Manure, in contrast, can vary considerably in nutrient content creating difficulties for accurate nutrient applications.
- Fertilizers and soil test recommendations express nutrient content in the same way; percent N, P_2O_5, and K_2O for nitrogen, phosphorus and potassium respectively. Manure values for these nutrients are expressed as percent total N, P and K. To avoid errors in calculating application rates, manure nutrient values must be converted to the same chemical form as reported in soil test recommendations (N, P_2O_5, and K_2O).
- Fertilizers contain simple inorganic forms of nutrients that are readily available to plants. In contrast, manure contains organic and inorganic nutrient forms with varying plant availability. This makes it difficult to estimate nutrient availability from manure and appropriate manure application rates to meet nutrient demands in the year of application.

- To help avoid over-application of nutrients, fertilizers can be custom blended to produce nutrient proportions based on soil test fertilizer recommendations. Manure has an imbalanced nutrient profile relative to what most crops require. This can lead to over or under-application of nutrients and increase environmental risk or reduced yield, depending on the nutrient.
- All nutrient applications have nuisance concerns such as odour, dust and noise. Unlike manure, odour is not an issue with fertilizer application.
- Fertilizers are a more concentrated source of nutrients on a weight basis. Higher nutrient concentration reduces product bulk. This reduces transportation costs per weight unit of nutrient and facilitates easier storage.

Table 2.3.2 summarizes the properties of fertilizers commonly used in Western Canada.

Table 2.3.2 Characteristics of Fertilizers Commonly Used in Western Canada

Fertilizer	% N-P_2O_5-K_2O (S)	Forms of Key Nutrients	Comments
Anhydrous Ammonia	82-0-0	NH_3/NH_4^+	• Highest N content of all N fertilizers.
Ammonium Sulphate	21-0-0-24S	NH_4^+, SO_4^{2-}	• Most common S fertilizer used in Alberta.
Urea	46-0-0	NH_3/NH_4^+	• Most popular form of granular N fertilizer used in Alberta.
Urea-Ammonium Nitrate	28-0-0/32-0-0	NH_3/NH_4^+, NO_3^-	• Most common liquid N fertilizer. • Half of the N is from urea and half is from ammonium nitrate.
Monoammonium Phosphate	12-51-0	NH_4^+, HPO_4^{2-} or $H_2PO_4^-$	• Most popular P fertilizer used in Alberta. • Often blended with potash.
Ammonium Polyphosphate	10-34-0	NH_4^+, HPO_4^{2-} or H_2PO_4	• Most common liquid P fertilizer.
Muriate of Potash	0-0-60	K^+, Cl^-	• Saskatchewan is the world leading producer of potash.
Urea-ammonium Sulphate	34-0-0-11S	NH_3/NH_4^+, SO_4^{2-}	• Not common in western Canada.
Ammonium Phosphate-sulphate	16-20-0-14S and 17-20-0-15S	NH_4^+, HPO_4^{2-} or H_2PO_4, SO_4^{2-}	• Primarily a home and garden fertilizer.
Sulphur Bentonite	0-0-0-90S	S^0/S^{2-}	• Contains 10% bentonite clay. • Can be blended with most other fertilizers. • To be plant available, microorganisms must oxidize elemental S.
Gypsum	0-0-0-18S	SO_4^{2-}, Ca^{2+}	• Lower solubility than ammonium sulphate. • Supplies Ca^{2+}.

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The impact of manure application on soil organic matter is influenced by the solids content of the manure (solid manure has a greater influence than liquid manure).

Manure

The following are some favourable characteristics of manure as a nutrient source:

- In most cases, manure is available for free or minimal cost. However, trucking and application costs can minimize this advantage.
- Manure can serve as a soil conditioner through the addition of organic matter. This can improve the physical structure and stability of soils, particularly degraded soils and those with low organic matter.
- Manure has a broad profile of macro- and micronutrients; although, the nutrients are not balanced relative to crop requirements.
- Manure contains nutrients in organic and inorganic (crop available) forms. The organic form functions as a slow release fertilizer, gradually releasing nutrients to the crop. However, the uncertain timing of nutrient release relative to crop demand and the nutrient carryover to subsequent years can complicate soil fertility management.

Manure and Fertilizer as Potential Environmental Contaminants

Manure or fertilizer can boost soil fertility for crop production; however, both can also pose a potential environmental risk. Improper handling, storage and application of manure or fertilizer create a risk of contamination to soil, water, and air quality.

Risks to Soil Quality

Improper manure and fertilizer management can adversely affect soil quality in the following ways:

- Livestock manure can be a rich source of soluble ions like sodium (Na^+) and potassium (K^+) because animals retain only a small amount of the salt they consume. Repeat applications of manure at rates exceeding agronomic requirements can contribute to saline soil conditions. Long-term buildup of Na can also have a negative impact on soil structure by reducing soil particle aggregation.
- Frequent traveling by loaded application equipment on wet soils can lead to soil compaction. Soil particles are squeezed together by compaction, reducing pore spaces available for air and water storage. This can inhibit root growth and increase surface runoff.

Risks to Water Quality

When manure or fertilizer is improperly handled or applied at rates exceeding crop requirements, contaminants including nutrients and pathogens can enter surface water and groundwater.

» Groundwater

Groundwater is an important source of water for many rural Albertans. Manure and fertilizer application pose several risks to groundwater including contamination from N, P, and pathogens. Manure and nitrogen fertilizer applications raise soil nitrate (NO_3^-) levels. Nitrate can leach into groundwater because it is soluble and mobile in soils. High-risk groups (e.g., infants and pregnant women) who consume water high in NO_3^- (i.e., above 10 ppm N or 45 ppm NO_3^--N) have a reduced ability to transport oxygen in their bloodstreams. This condition is referred to as methemoglobinemia (“blue baby syndrome”).

Most soils in Alberta have a strong ability to adsorb (bind) P, which limits its entry into groundwater. However, leaching can occur when the soil’s adsorption capacity is saturated with high levels of P. This can happen from over-application of manure, particularly on coarse textured soils in high-rainfall or irrigated areas.

Transmission of manure pathogens to groundwater is rare, but can occur on coarse textured soils with high

water tables. It can also happen when contaminated runoff enters groundwater through an improperly installed or poorly maintained well.

The Walkerton Tragedy

In 2000, seven people died and over 2300 became ill in the rural community of Walkerton, Ontario when the town's water supply was contaminated with *E. coli* and *Campylobacter*. These potent pathogens are often implicated in food and water-borne illness.

The contamination source was runoff from a recently manured field, which entered the water system through an improperly protected well. While the producer was not responsible for the tragedy, it underscores the importance of doing a thorough site assessment prior to manure application.

Source: Ontario Ministry of the Attorney General

» Surface Water

Agricultural runoff contaminated with nutrients and pathogens is the primary risk to surface water quality. Eutrophication is the enrichment of surface water bodies by nutrients, particularly N and P. Phosphorus is often the first limiting nutrient in surface water ecosystems. Excess P entering surface water from runoff or P contaminated groundwater can result in increased algae production. Large algae blooms can significantly deplete oxygen levels when they die and decompose. Oxygen depletion will negatively affect aquatic animals. Blooms of blue-green algae (cyanobacteria) can also release toxins that are harmful to aquatic life, livestock and wildlife if they ingest the water. Eutrophication is a natural occurrence that is accelerated by human activities.

Transmission of manure pathogens to surface water is more likely than groundwater contamination. Surface water contamination by manure pathogens can occur on fine textured soils prone to erosion, or in situations where manure is applied or deposited too close to surface water bodies. For example, livestock that have direct access to water bodies can pose a significant risk to surface water quality.

Risks to Air Quality

Manure and fertilizer application can also adversely affect air quality. For example, ammonium (NH_4^+) in manure or fertilizer converted to ammonia (NH_3) gas can be lost to the atmosphere. This is a particular concern with unincorporated surface applications of manure or urea (46-0-0). Ammonia losses are reduced with subsurface applications and when surface applied products are thoroughly incorporated.

Odour emissions are a risk when surface applied products are not incorporated.

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High NO_3^- levels in drinking water can also affect livestock productivity.

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N losses via agricultural runoff are generally minor in comparison to P losses.

summary

- Fertilizer has several advantages over manure including: standardized nutrient content, readily plant available nutrients, can be blended to meet crop requirements, higher nutrient concentration and more easily handled.
- The advantages of manure relative to fertilizer include: minimal cost, provides a broad nutrient profile, provides nutrients both immediately and slowly over time, and has soil conditioning benefits.
- The major risks to soil quality from manure application are increased salinity and soil compaction due to use of application equipment during high-risk periods (e.g., wet spring season).
- The major risk to groundwater quality from nutrient application is NO_3^- leaching to groundwater sources, this has potential human and animal health concerns.
- The major risk to surface water is increased eutrophication resulting from nutrients carried to surface water bodies from manured or fertilized fields.
- Manure pathogens transmitted to surface water can pose a significant risk to human and animal health if consumed.
- Odour from manure application can adversely impact air quality, particularly with surface application without incorporation.