MANURE STORAGE AND HANDLING

Manure is a source of greenhouse gas. Solid manure is aerobic and emits carbon dioxide as it decomposes. The wetter portions of stored solid manure emit nitrous oxides. Liquid manure is anaerobic by nature and emits methane.

Livestock producers who have completed a nutrient management plan know that manure storage is a key consideration. Properly designed and sized storage systems result in less net nutrient loss, better containment of contaminated liquids, and reduced odours. These systems also reduce gaseous losses, particularly of ammonia, which affects the nitrogen content of the manure and its value as a fertilizer.

Livestock manure is handled and stored as a solid, semi-solid or liquid. Manure form depends on the type of livestock manure and what's added – the amount of dilution water plus the type and volume of bedding used. In Ontario, most livestock operations have either solid or liquid systems.

Solid manure emits nitrous oxides, and straw (bedding) is the main culprit. Long straw is worse than short or chopped straw (10 times more). Wheat and barley straw systems combined emit more than barley (1.5 times more). Covering manure with straw also increases greenhouse gas emissions. Summer emissions exceed winter emissions due to increased bio-activity.

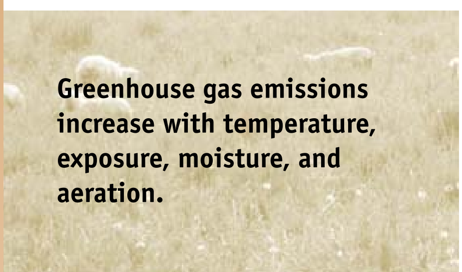
Liquid manure emits methane and ammonia. Most of the greenhouse gas from manure is methane from liquid manure.

Methane emissions depend on:

- ▶ manure volume – livestock numbers, feed and digestibility
- ▶ methane-producing potential – varies by manure and livestock type, feed quality
- ▶ manure storage and handling – liquid vs. solid, length of storage (e.g., over summer).

Most emissions from manure are from the storage of liquid manure (up to 80% of total emissions from manure):

- ▶ CO_2 loss was measured to be 20–30% of total carbon for cattle



Greenhouse gas emissions increase with temperature, exposure, moisture, and aeration.

Most manure-based emissions are from the microbial processes of anaerobic decomposition and partial denitrification.

- composted beef and dairy manure emits the least greenhouse gases relative to solid stacked and liquid
  - liquid emits 2–3 times more than piled solid
  - beef manure stored in piles emits 20 times more than compost (6 times more than composted dairy manure)
- manure is the prime source of greenhouse gas (methane and nitrous oxide) from the pork industry.

Most greenhouse gas emissions from agriculture come from stored manure during the first few months, due to anaerobic decomposition and denitrification.

Liquid manure storages are a source of methane from anaerobic decomposition, and of nitrous oxide due to denitrification from the crust of liquid manure storages. They can also be a large source of NH_3: 60–80% is lost from pig manure earthen storage, as a function of exposure, water content and pH.

Generally, larger operations have liquid systems to manage all liquids in the operation. Washwaters and, for dairy operations, milking centre wash liquids, are used to dilute the manure produced. This makes manure easier to handle. However, unless the manure is applied more than once a year, it is a source of greenhouse gases.

Managing all liquids is also important with solid systems. Clean water should be diverted, and contaminated waters (such as yard runoff) should be stored and managed separately – that's why some solid systems have separate liquid storages. This runoff can then be land-applied to supply additional nutrients to growing crops.

MANURE SYSTEMS AND GREENHOUSE GAS IMPACTS

MATERIAL	N_2O	CH_4	CO_2	NH_3
SOLID MANURE	High	Low	High	Medium
COMPOSTED SOLID MANURE	Medium to high	Low to very low	Very high	High to very high
LIQUID MANURE	Low	High	Low to medium	High to very high
COVERED LIQUID MANURE	Low	Medium	Low	High

BMPs FOR SOLID MANURE SYSTEMS

✔ **Keep bedding and manure dry and clean.**
For poultry, maintaining bedding moisture at 20–25% will reduce odour and NH_3 losses associated with damper litter or manure conditions. Some of the means to prevent excess water contamination include adjusting the height of drinkers to avoid spillage, and proper sanitation and ventilation.

✔ **Keep stored manure covered.**
Solid poultry pack manure with 25% moisture will emit less methane and nitrous oxide than manure storage and handling systems with more moisture. A shallow, solid pack manure system emits less than a deep, solid pack system.

✔ **Ensure proper ventilation.**
Use rapid-drying technologies to reduce microbial decomposition. Use belts, or slotted or ventilated floors.

✔ **Divert runoff and washwaters away from stored manure.**
Keep manure dry and minimize anaerobic areas that will emit nitrous oxide.

✔ **Remove manure from yards, feedlots and bedding areas frequently.**
This helps to keep manure dry.

✔ **Spread and incorporate more than once a year.**
This will reduce anaerobic conditions and subsequent methane release.

Covered manure storages are preferred.

Wet bedding and solid manure are sources of ammonia, methane and nitrous oxide. Keep solid manure as dry as possible.

Dry bedding emits less ammonia.

COMPOSTING

Is composting net-positive or net-negative for greenhouse gas? Carbon and nitrogen are placed in more stable forms, but how much ammonia and carbon dioxide are lost during the process of decomposition (composting)?

In theory, more aeration will lead to aerobic decomposition and CO_2 production (rather than methane). Poorly managed composting processes result in increased methane and ammonia generation. Composted manure produced 7% and 80% less CO_2 equivalents than raw manure in winter and summer respectively. Generally, 25% less greenhouse gas is produced from composted manure vs. raw manure systems. Other studies found that passive aeration of composted manure generated approximately two times more net greenhouse gas than actively composted manure.

There are fewer nutrients in runoff from compost than from raw manure. During the composting process, ammonia and methane are emitted at the initial phases and nitrous oxide during the mid-phases.

To compost poultry manure to a stable endpoint: maintain moisture at 40–60% (greater than 60% can result in leaching), temperatures at 135–145°F, sufficient oxygen from turning for aerobic decomposition, and pH of 5.5–7.5 (greater than 8 results in ammonia volatilization).

Properly composted manure will emit less greenhouse gas than raw manure.

BMPs FOR LIQUID MANURE SYSTEMS

✔ **Reduce manure liquid content.**
Divert clean water, washwaters and wastewaters away from storage. This will reduce anaerobic conditions conducive to ammonia and methane emissions.

✔ **Cover storage where possible.**
Covering manure storage will reduce emissions.

✔ **Agitate and aerate to reduce anaerobic conditions in order to lower methane emissions.**
This will convert ~30% of the carbon materials to CO_2, but will not prevent anaerobic decomposition. Use passive agitation or alternative energy source to drive agitator/aerator.

✔ **Reduce storage time with more frequent applications. Use side-dress applications to reduce methane and ammonia emissions.**

✔ **Treat manure.**
Use solid–liquid separation or anaerobic digestion to reduce emissions and convert them to renewable energy.

Liquid manure storages are sources of methane and ammonia.

CONSIDERATIONS FOR COVERS

Covering storages can reduce temperature and methane. Ninety percent of manure's methane potential is lost to the atmosphere from earthen manure storages. Covered storages can also reduce additional moisture, accelerate anaerobic conditions, and lessen the amount of methane lost.

However, straw covering of stored liquid dairy and pig manure can increase emissions depending on the greenhouse gas, straw type and length, and season. Straw and other high-carbon bedding are a source of food and energy for microbes. Some of these microbes will convert carbon compounds to methane and others will reduce nitrogen compounds to nitrous oxide.

Winter covering with straw can reduce N_2O, CH_4 and CO_2 emissions by 12%, 87% and 53% respectively, whereas summer covering of stored liquid manure will have the opposite effect with increases of 42%, 55% and 33% respectively. Covered storages and reduced temperatures can reduce NH_3 losses by up to two-thirds.

Studies of other covers revealed:

- a thin layer of mineral oil was found to reduce NH_3 loss by two-thirds
- ammonia can be trapped by acidic peat in the form of ammonium ($NH_3 + H^+ = NH_4^+$).

Divert clean water away from manure storages to reduce emissions.

Energy-passive agitation and aeration systems will introduce oxygen and reduce emissions.

Manure treatment such as solid-liquid separation can reduce emissions.

LIVESTOCK YARDS

Livestock yards can be paved or soil-based. As we've seen, anaerobic conditions will generate greenhouse gas. Maintenance can reduce anaerobic conditions and reduce soil mixing of manure and bedding, which in turn will reduce methane and N_2O production. By removing manure wastes frequently, you can reduce methane and N-oxide by 10%.

MANURE SYSTEMS AND TREATMENTS AND GREENHOUSE GAS IMPACTS

GREENHOUSE GAS	WINTER AND SPRING *	SUMMER *
AMMONIA	0.27 $g/m^2/day$	0.45 $g/m^2/day$
NITROUS OXIDE	3.3 $ug/m^2/day$	6.5 $ug/m^2/day$
METHANE	185 g/m^2	57.3 g/m^2

*if feeding areas included

BMPs FOR FEEDLOT AND YARD RUNOFF MANAGEMENT

Livestock yards and feedlots are used by dairy and beef producers to provide confined outdoor space for feeding, exercising or loafing. Whether paved or dirt, they are located to take advantage of natural slopes so that rain and roof runoff helps keep these areas clean.

Yard runoff contains nutrients and organic material. Unless managed effectively, yard runoff can put groundwater and surface water at risk of contamination.

✔ **Determine the risk of contamination.**
Consider livestock numbers, the size and other physical characteristics of the lot, as well as rainfall intensity, duration, and frequency.

✔ **Divert uncontaminated water.**
Water from rain, snow, snowmelt, roofs and eaves should not have contact with manure on exercise yards.

✔ **Clean paved areas regularly.**

✔ **Fence cattle out of any manure and runoff storages.**

Maintenance can reduce methane and nitrous oxide production.

BMPs FOR MANAGING RUNOFF FROM FEEDLOTS AND YARDS

BMP OPTION	DESCRIPTION	TIPS
DIVERT CLEAN WATER  **A well-designed eaves system can divert clean water away from manure storages.**	• Roof the yard or scrape manure to roofed area. All roofs that would contribute to runoff from the feedlot should have gutters, downspouts, and outlets that discharge water away from the feedlot. • Where roofing is not practical or feasible, clean water diversion and frequent maintenance will still complement other management systems.	• To complement this expensive option, follow a strict manure maintenance program. • To reduce the volume of contaminated water produced and the amount of solids eroded from the lot, try these measures: ○ adequate eaves, rainwater diversion, clean water drainage system (independent of any wastewater system) and in some cases, berms to divert severe storm and meltwater runoff from upslope of the facility.
DIVERT UNTREATED WATER AND MANURE TO LIQUID STORAGE  **Yard runoff can be diverted to liquid manure storages.**	• Yards need to be designed to convey contaminated water and all precipitation (including storm events) to the liquid storage. • Provide diversion to separate storage (suitable for dirt livestock yards and feedlots).	• Concrete curbs, gutters and an outlet must be part of the paved yard design. • These systems work best with the following management practices: scraping of manure, bedding and wasted feed, plus unplugging the outlet area. • Yards need to be shaped to channel contaminated water and all precipitation (including storm events) to the designated storage (pond/earthen storage). • Properly designed curbs, concrete gutters or grassed diversions and a picket-fence outlet must be part of the paved yard design. • These systems will ONLY work effectively with the following management practices: scraping of manure, bedding and wasted feed, as well as unplugging the outlet area.
DIVERT AND TREAT RUNOFF  **Vegetative filter strips can reduce anaerobic conditions by treating yard runoff.**	• Lot runoff is diverted to a vegetated filter strips system designed to intercept and treat runoff by settling, filtration, dilution and absorption of pollutants, and infiltration into the soil. • Runoff can be collected and transferred by diversions, curbs, gutters, lot paving, and, in some cases, by pumping. • A settling basin is needed to remove solids. Liquids go to a vegetative infiltration area where the liquid is filtered and infiltrates the soil.	• Liquid materials from separate storages can be managed like liquid manure IF solids are prevented from entering pond or they can be part of a treatment system.