GREENHOUSE GAS FROM DAIRY MANURE MANAGEMENT AT THE FARMSTEAD
Part 2: DAIRY MANURE MANAGEMENT IMPACT ON METHANE

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Daily spreading of manure is being reduced since it can result in water quality and nutrient recycling concerns. Long-term manure storage to avoid spreading when the potential for runoff occurs during frozen, snow covered or saturated conditions is encouraged. This helps to maximize nutrient recycling and to reduce nutrient and potential pathogen losses to ground and surface water. Long-term storage is a water quality best management practice. However it can increase a farm's greenhouse gas (GHG) footprint by releasing GHGs – methane (CH_4) with a Global Warming Potential (GWP) of 34 and Nitrous Oxide (N_2O) with a GWP of 298. Since the GWP of GHG are different they are often expressed as carbon dioxide equivalents (CO_2eq). The calculations and justifications used to quantify CH_4 emissions from anaerobic (no free oxygen available) manure management methods are shown below.

Quantifying Dairy Manure Storage CH_4 Emissions per Cow

The daily CH_4 emission (lbs./cow-day) can be estimated using Equation 1.2 (IPCC, 2006). Yearly emissions can be estimated by summing the daily emissions (or multiplying by 365 days, when an average yearly value for the methane conversion factor (MCF) is used).

The two variables that can be controlled by the farm management are the long-term storage Volatile Solid (VS) loading and the MCF depending on the type of manure management system. Cows' diets can potentially change and impact the VS in the manure. Processing manure with solid-liquid separation (SLS) to remove a portion of the VS from the liquid effluent sent to the long-term storage would significantly reduce the CH_4 emissions from the liquid storage system proportionate to the percent VS removed.

The MCF is lower for those systems that are more aerobic (free oxygen available) and higher for those systems that are more anaerobic. The MCF are dependent on temperature and will change throughout the year as the manure storage temperature changes.

Table 1.2 provides a summary of the MCF values from the IPPC (2006) and EPA (2016) documents. For example, summer ambient temperature was assumed to be 18°C (64°F) and winter was assumed to be < 10°C (< 50°F). MCF values for other temperatures are contained in the source documents. It is recognized that the MCF values given may vary by as much as 50% (IPCC 2006) at specific sites due to variations in length

Equation 1.2 $CO_2eq = VS \times B_0 \times 0.044 \times (MCF/100) \times 34\ (CO_2/CH_4)$

CO_2eq = Equivalent GWP expressed as carbon dioxide (lbs. CO_2eq /cow-day)
VS = Total volatile solids in manure =16.9 lbs./cow-day (ASAE)
B_0 = Maximum CH_4 producing capacity for manure = 3.84 ft^3 CH_4/lb. VS degraded (for dairy cow manure)
0.044 = Conversion factor of ft^3 CH_4 to lb. CH_4
MCF = CH_4 conversion factor for the manure management system (see Table 1.2)
34 = GWP factor for CH_4

Table 1.2 Representative methane conversion factors[1] selected for dairy manure management water quality BMPs

MCF	Manure Management BMP	Condition
0.1	Daily spread	Winter (< 10°C)
0.5	Daily spread	Summer (18°C)
2	Solid storage	Winter < 10°C
4	Solid storage	Summer 18°C
10	Liquid/Slurry with natural crust	Winter < 10°C
22	Liquid/Slurry with natural crust	Summer 18°C
17	Liquid/Slurry without natural crust	Winter < 10°C
35	Liquid/Slurry without natural crust	Summer 18°C
3	Pit storage below animal confinement	<1 month Summer 18°C
17	Bedded pack winter	< 10°C
35	Bedded pack summer	18°C
0.5	Compost static pile	Winter and Summer
0.5	Compost windrow	Winter < 10°C
1	Compost windrow	Summer 18°C
Varies from 0-100	Anaerobic digestion	0 if all CH_4 is captured and combusted 100 if all CH_4 is released

[1]Source: IPCC (2006) and EPA (2016)

of storage, completeness of storage emptying and temperature variation.

Looking at the MCF values alone shows that for most management systems winter emissions will be about half of summer emissions. This is because CH_4 production is a biological process that is temperature dependent.

Using representative winter and summer temperatures, average MCF values can be used in Equation 1.2 to estimate average methane emissions for these 6-month "summer" and "winter" periods and compare different manure management systems. Solid storage and/or composting has a much lower MCF than liquid storage but may produce some GHG as N_2O. Solid-liquid separation VS removal rates vary depending on the technology and management. See fact sheet 3 for information on N_2O emissions with these manure management systems. The combination of the GWP of both CH_4 and N_2O emissions need to be included in determining the impact of the manure management system on GHG emissions.

Authors

Peter Wright, PE pew2@cornell.edu (585) 314-5314 ***Curt Gooch***, PE cag26@cornell.edu (607) 225-2088

Fact sheet series: 1 How are Greenhouse Gases Generated?, 2 Dairy Manure Management Impact on Methane, 3 Dairy manure management impact on Nitrous Oxide, 4 Combining Methane and Nitrous Oxide Emissions from Dairy Manure Management, 5 GHG Reduction from Crusts on Storages, 6 GHG Reduction from Limiting Summer Storage, 7 GHG from Solid Storage Systems, 8 GHG Reduction from Solid/Liquid Separation, 9 GHG Reduction from an Impermeable Cover, 10 GHG Reduction from an Anaerobic Digestion System.

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Intergovernmental Panel on Climate Change (IPCC) Tier 2 method from the 2006 IPCC Guidelines for National GHG Inventories, Volume 4, Chapter 10:

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