GREENHOUSE GAS FROM DAIRY MANURE MANAGEMENT AT THE FARMSTEAD

Part 4: COMBINING METHANE AND NITROUS OXIDE EMISSIONS FROM DAIRY MANURE MANAGEMENT

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The global warming potential (GWP) from GHG emitted from dairy manure management systems needs to include both GHG emissions of methane (CH_4) and nitrous oxide (N_2O). Using equation 1.2 from fact sheet 2 and equation 1.3 from fact sheet 3 along with their respective tables for 1.2 for methane contributing factor (MCF) and table 1.3 emission factor (EF3) for N_2O emissions will give the combined GWP for the manure management system.

Table 1.4 shows the MCF, EF_3, and the carbon dioxide equivalent (CO_2eq) per cow per year calculated using a GWP for CH_4 of 34 and a GWP for N_2O of 298 (Myhre et al. 2013). The assumptions used are that each manure management system that stores manure stores it for both the summer period and the winter period, the nitrogen content of the manure excreted is 0.99 lbs./ cow-day (ASAE), the volatile solids (VS) in manure assumed to be 18°C (64°F) and winter is is16.9 lbs./cow-day (ASAE), and that for simplicity, summer ambient temperature is assumed to be < 10°C (< 50°F) so an average MCF value is used for the whole year.

Daily spread may have the lowest GWP of the manure handling system but it also may have the most negative impact on water quality as nutrients are applied at times when they may be more subject to loss before they can be utilized by a growing crop. The more the manure management system is anaerobic the more CH_4 is produced. The more the manure management system is aerobic the more N_2O is produced. A composted bedded pack combines both the anaerobic and aerobic production for the highest GWP of the manure management systems. Solid storage with no mixing has a lower GWP than liquid

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 1.4)
34 = GWP factor for CH_4

Equation 1.3:

$$CO_2\ eq = 298\ CO_2/N_2O\ GWP \times EF_3 \times 44\ N_2O/28\ N_2O\text{-}N \times N\ excreted/cow\text{-}day$$

CO_2eq = Equivalent GWP expressed as carbon dioxide
298 = GWP factor for N_2O
EF_3 = Emission Factor for N_2O emissions from manure management (see Table 1.4)
N Excreted /cow-day = ~0.99 lbs./cow – day (ASAE).

Table 1.4 GWP estimates[2] for selected dairy manure management systems

MCF[1] (winter - summer)	EF_3[1]	Manure Management System	Annual GWP lbs. from CH_4 CO_2eq/cow/yr.[2]	Annual GWP lbs. from N_2O CO_2eq/cow/yr.[2]	Total Annual GWP lbs. CO_2eq/cow/yr.[2]
(0.1 – 0.5)	0	Daily spread[3]	106	-0	106
(2 – 4)	0.005	Solid storage	1,063	846	1,909
(10 – 22)	0.005	Liquid/Slurry with natural crust	5,670	846	6,516
(17 – 35)	0	Liquid/Slurry without natural crust	9,213	- 0	9,213
(17 – 35)	0.01	Bedded pack no mixing	9,213	1,692	10,905
(17 – 35)	0.07	Bedded pack, active mixing (composted bedded pack)	9,213	11,845	21,058
0.5	0.006	Compost static pile	177	1,015	1,192
(0.5 – 1)	0.01	Compost windrow, infrequent turning	266	1,692	1,958
(0.5 – 1)	0.1	Compost windrow, frequent turning	266	16,922	17,187

[1]Source: IPCC (2006) and EPA (2016) [2]Calculated [3]Daily spread has no storage GWP is from spreading.

storage. Solid storage and composting that are mixed have the highest GWP as they provide the highest potential for N_2O production. Additional fact sheets in this series go into detail and discuss ways to reduce GHG emissions. Not all of these methods will work on every farm due to specific existing facility constraints.

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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.

References:

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