

## 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<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O). 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 (EF<sub>3</sub>) for N<sub>2</sub>O emissions will give the combined GWP for the manure management system.

Table 1.4 shows the MCF, EF<sub>3</sub>, and the carbon dioxide equivalent (CO<sub>2</sub>eq) per cow per year calculated using a GWP for CH<sub>4</sub> of 34 and a GWP for N<sub>2</sub>O 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 is 16.9 lbs./cow-day (ASAE), and that for simplicity, summer ambient temperature is assumed to be 18°C (64°F) and winter 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<sub>4</sub> is produced. The more the manure management system is aerobic the more N<sub>2</sub>O 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**

$$\text{CO}_2\text{eq} = \text{VS} \times \text{B}_0 \times 0.044 \times (\text{MCF}/100) \times 34 \text{ (CO}_2\text{/CH}_4\text{)}$$

CO<sub>2</sub>eq = Equivalent GWP expressed as carbon dioxide (lbs. CO<sub>2</sub>eq /cow-day)

VS = Total volatile solids in manure = 16.9 lbs./cow-day (ASAE)

B<sub>0</sub> = Maximum CH<sub>4</sub> producing capacity for manure = 3.84 ft<sup>3</sup> CH<sub>4</sub>/lb. VS degraded (for dairy cow manure)

0.044 = Conversion factor of ft<sup>3</sup> CH<sub>4</sub> to lb. CH<sub>4</sub>

MCF = CH<sub>4</sub> conversion factor for the manure management system (see Table 1.4)

34 = GWP factor for CH<sub>4</sub>

#### **Equation 1.3:**

$$\text{CO}_2 \text{ eq} = 298 \text{ CO}_2\text{/N}_2\text{O GWP} \times \text{EF}_3 \times 44 \text{ N}_2\text{O}/28 \text{ N}_2\text{O-N} \times \text{N excreted/cow-day}$$

CO<sub>2</sub>eq = Equivalent GWP expressed as carbon dioxide

298 = GWP factor for N<sub>2</sub>O

EF<sub>3</sub> = Emission Factor for N<sub>2</sub>O emissions from manure management (see Table 1.4)

N Excreted /cow-day = ~0.99 lbs./cow – day (ASAE).

**Table 1.4 GWP estimates<sup>2</sup> for selected dairy manure management systems**

MCF <sup>1</sup> (winter - summer)	EF <sub>3</sub> <sup>1</sup>	Manure Management System	Annual GWP lbs. from CH <sub>4</sub> CO <sub>2</sub> eq/cow/yr. <sup>2</sup>	Annual GWP lbs. from N <sub>2</sub> O CO <sub>2</sub> eq/cow/yr. <sup>2</sup>	Total Annual GWP lbs. CO <sub>2</sub> eq/cow/yr. <sup>2</sup>
(0.1 – 0.5)	0	Daily spread <sup>3</sup>	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

<sup>1</sup>Source: IPCC (2006) and EPA (2016) <sup>2</sup>Calculated <sup>3</sup>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<sub>2</sub>O 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:

- ASAE D384.2 MAR2005 (R2010) Manure Production and Characteristics ASABE, 2950 Niles Road, St. Joseph, MI 49085-9659, USA
- Environmental Protection Agency. April 15, 2016. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2014,
- Intergovernmental Panel on Climate Change (IPCC) Tier 2 method from the 2006 IPCC Guidelines for National GHG Inventories, Volume 4, Chapter 10:
- Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestedt, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura and H. Zhang (2013) "Anthropogenic and Natural Radiative Forcing". In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.
- Wright, Peter, Curt Gooch, J.P. Oliver, "Estimating the Economic Value of the Greenhouse Gas Emission Reductions Associated with on-farm Dairy Manure Anaerobic Digestion Systems in New York State". Paper number 1700626, 2017 ASABE Annual International Meeting. (doi: 10.13031/aim.201700626) @2017 Joseph, MI 49085-9659.