GREENHOUSE GAS FROM DAIRY MANURE MANAGEMENT AT THE FARMSTEAD

Part 3: DAIRY MANURE MANAGEMENT IMPACT ON NITROUS OXIDE

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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 N_2O emissions from several aerobic (free oxygen present) manure management methods are shown below.

Quantifying Daily Manure-Based N_2O Emissions per Cow

The daily N_2O emissions converted into CO_2eq can be estimated using Equation 1.3 from the IPCC (2006) and EPA (2009) from N_2O emissions from several different manure management methods. Yearly emissions can be estimated by multiplying the average daily emissions by 365 days.

The two variables that can be controlled by farm management are the daily mass of nitrogen (N) excreted by the animals related to their feed diets and the emission factor (EF_3) depending on the manure management system. The N_2O emissions from manure management are less defined than CH_4 emissions with an estimated uncertainty range of a factor of 2 (200%) (IPCC, 2006). N_2O is emitted when the complete biological oxidation of nitrogen to nitrate (NO_3) is interrupted. Table 1.3 provides a summary of the EF_3 values from the IPPC (2006) and EPA (2016) documents for the N_2O emission factor values for various manure management BMPs.

Although the EF_3 values are less than the MCF values used for CH_4 emission N_2O is 8.7 times the GWP of CH_4 so the GWP from aerobic manure management practices can be significant. Of these manure management practices the most aerobic manure management methods have the highest potential for N_2O emission. Processing manure with solid-liquid separation (SLS) to remove a portion of the N from the solid portion sent to the long-term storage would significantly reduce the N_2O emissions from a more aerobic (actively composted) system since the liquid long-term storage would still contain most of the N leaving much less N in the solid storage (Gooch et al., 2005).

Equation 1.3

$$CO_2eq = 298\ CO_2/N_2O\ GWP \times EF_3 \times 44\ N_2O/28\ N_2O\text{-}N \times N\ \text{excreted/cow-day}$$

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 1.3)
N Excreted /cow-day = ~0.99 lbs./cow – day (ASAE).

Table 1.3 Approximate emission factors[1] for N_2O (lb. N_2O-N/lb. N)

EF_3	Manure Management BMP	Condition
0	Daily spread	N/A
0.005	Solid storage	N/A
0.005	Liquid/slurry	With natural crust
0	Liquid/slurry	Without natural crust
0.002	Pit storage	Below animal confinement
0.01	Bedded pack	No mixing
0.07	Bedded pack	Active mixing (composted bedded pack)
0.006	Compost pile	Static
0.01	Compost windrow	Infrequent turning
0.1	Compost windrow	Frequent turning
0	Anaerobic digestion	N/A

[1]Source: IPCC (2006) and EPA (2009)

Nitrogen removal rates for various SLS technologies also vary depending on technology and management. See fact sheet 2 for information on CH_4 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. Fact Sheet 4 combines both the CH_4 and N_2O emissions from several common dairy manure management systems. Additional fact sheets discuss ways to reduce GHG emissions although a specific farm may only be able to implement certain ones depending on their existing facilities.

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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.

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

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