GREENHOUSE GAS FROM DAIRY MANURE MANAGEMENT AT THE FARMSTEAD

Part 1: How are Greenhouse Gases Generated?

August 2017

Greenhouse gas (GHG) emissions are becoming a greater concern in the United States (US), and generally throughout the world. The milk production food chain from farm to the consumer in the US was analyzed for its carbon footprint (Thoma et al. 2013). Manure contributes 23% of the overall dairy value chain emissions of GHG. Emissions from manure used as fertilizer was included in the field production portion of the food chain analysis. Since manure is typically removed from the barn most of the GHG production from manure at the farmstead occurs when it is stored long-term.

Long-Term Manure Storage

Although long-term manure storage is commonly implemented as a water quality Best Management Practice (BMP), long-term manure storage creates GHG emissions, primarily from methane (CH_4) in anaerobic (no free oxygen) conditions but also nitrous oxide (N_2O) in aerobic (free oxygen present) conditions.

The capability to store manure long-term reduces or eliminates the need to recycle manure to cropland on a daily basis. Long-term storage has been encouraged with both technical and cost-share programs from both state and federal governments to reduce the potential for nutrient loss from runoff or flow to ground water. Dairy manure is most often stored as an anaerobic liquid. As produced, manure is only 10-12% solids. Under some management schemes where additional organic material is added to the manure, it can be stored as a solid (>30% solids) with the opportunity for aerobic conditions especially on the exposed edges or when mixed.

GHG Emissions from Stored Manure

Manure contains volatile solids (VS); VS are organic carbon compounds and some can be precursors of CH_4. The amount of VS in manure is somewhat dependent on the type and size of animals and their diets. Additions of organic matter from off-farm or waste feed mixed with manure can increase the amount of VS stored on-farm. Not all of the biologically degradable VS is readily degraded under anaerobic conditions as found within liquid manure storages. The portion of VS that is degraded results in CH_4 production. The equation used to predict CH_4 emissions from various manure management methods is contained in part 2 of this series: DAIRY MANURE MANAGEMENT IMPACT ON METHANE.

Manure also contains various nitrogen (N) compounds that can be precursors of N_2O. More aerobic manure management conditions (e.g. composting manure solids) prevent CH_4 production. However shifting to aerobic conditions can be detrimental to GHG reduction since when manure is stored more anaerobically, the N in the manure is not oxidized, precluding N_2O production. Converting an existing liquid manure system to a solid manure system can be very costly and generally cost prohibitive for the farm to implement. But when manure is stored in more aerobic conditions, N_2O can be released. The equation used to predict N_2O emissions from various manure management methods is contained in part 3 of this series

Dairy Manure Management Impact on Nitrous Oxide. The amount (mass) of N emitted (as NH_4 or N_2O) is also dependent on the animal diet and can be controlled by precisely balancing the protein needs of the herd. If the molecular amounts are the same it is more important to control N_2O than CH_4 because CH_4 is 34 times more potent as a GHG than carbon dioxide (CO_2) and N_2O is 298 times more potent using a 100-year time scale (Myhre et al., 2013). This potency scale is referred to as the Global Warming Potential (GWP).

When CH_4 is combusted or oxidized it converts to CO_2, and water vapor, following the governing chemical formula:

$$CH_4 + 2O_2 = CO_2 + 2H_2O$$

Both the hydrogen and carbon were recently extracted from the environment by the plants fed to the cattle so returning H_2O and CO_2 to the environment has no net GHG impact; therefor the higher GWP impact of the CH_4 can be avoided by a combustion process.

Nitrous oxide in the atmosphere is very slowly converted to NO or N_2. Neither of these two by-products are a GHG, however the very high GWP of N_2O is attributed to its long lifespan.

GHG Reduction From Long-Term Storage

There are multiple practical ways to reduce the GHG emissions from long-term storages. These methods are explained in this fact sheet series. Not all of these methods will work on every farm due to specific existing facility constraints.

Authors

Peter Wright, PE pew2@cornell.edu (585) 314-5314 ***Curt Gooch***, 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 at the Farmstead, 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:

Myhre, G., D. Shindell, F.M. Bréon, W. Collins, J. Fuglestvedt, 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: T.F. Stocker, et. al., editors, Climate change 2013: The physical science basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York, NY

Thoma, Greg, Jennie Popp, Darin Nutter, David Shonnard, Richard Ulrich, Marty Matlock, Dae Soo Kim, Zara Neiderman, Nathan Kemper, Cashion East, Felix Adomd, Greenhouse gas emissions from milk production and consumption in the United States: A cradle-to-grave life cycle assessment circa 2008, International Dairy Journal 31 (2013) S3eS14

This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award number 2013-68002-20525.