Dairy Manure Management & Methane

by Paris Reidhead

Editor’s note: Writer Paris Reidhead takes a long look at the emerging, hot topic of dairy manure and greenhouse gases. His facts and conclusions are both sobering and enlightening. Livestock agriculture is in the spotlight of needs to reduce greenhouse gas (GHG) emissions.

Animal waste management can be either an opportunity or a failure for dairy, in a future environment that closely scrutinizes GHG generation. Producing and burning methane from livestock waste is an environmental folly.

Burning a pound of methane (CH4) combusted yields 2.75 pounds of carbon dioxide (CO2). CO2 dramatically boosts global climate change.

President Barack Obama and the U.S. Secretary of Agriculture Tom Vilsack are trying to get a livestock greenhouse gas (GHG) emissions reduced by 25% by 2020. Toward that end, a program is proposed in which dairy farms with 1,000 or more animal units would be financially assisted in installing anaerobic methane digesters. The digesters would reduce methane released into the atmosphere, as well burn the captured methane to generate electricity. Problem is: dairy manure should not be generating methane in the first place, if the wastes are properly managed.

Methane is a BAD GHG!

Methane is 21 times as potent a GHG, pound for pound, as carbon dioxide (CO2). The balance of the input rate and the removal rate determines atmospheric concentrations of GHG. Dairy will see a greater impact on reducing global warming by concentrating on methane reduction in the medium-term. That’s because methane is a short-lived gas in the atmosphere and poses a higher global warming threat. Some 60% of global methane emissions come from anthropogenic (human-influenced) sources. The remaining 40% are from natural sources. Issues associated with animal manure storage are considered anthropogenic.

According to Professor Michael Oppenheimer at Princeton University, methane is 21 times as potent a GHG, pound for pound, as carbon dioxide. Methane is 21 times as potent a GHG, pound for pound, as carbon dioxide. Methane is 21 times as potent a GHG, pound for pound, as carbon dioxide. Methane is 21 times as potent a GHG, pound for pound, as carbon dioxide.

NYC eggheads way off base, too

The nature of this problem, particularly as it relates to livestock, is addressed by folks with varying levels of limited expertise. A high-powered meeting of the minds convened in New York City on December 12, 2009 to address global warming and come up with official recommendations. These folks claimed that livestock cause almost one-third of the planet’s GHGs, as animals belch out carbon dioxide from one end, and emit methane from the other end! This Greenhouse Gas Emissions Conference was held in New York City, under the strong endorsement of Scott Stringer, Manhattan Borough President.

For this program to work a thought-provoking event, all of whom were asked to sign the New York City Food Pledge and Charter. This document included 10 principles for a Sustainable Food System. “Principle #4” addressed the environment as follows:

“...the food system, largely due to the livestock industry, is estimated to cause one-third of the world’s global warming. To lessen environmental harm, New York City should reduce greenhouse gas emissions resulting from the production, distribution, sale and disposal of food. Such efforts should increase the amount of food produced and processed regionally by farmers using sustainable practices.” The first sentence of Principle #4 raises the eye-brows of intelligent animal scientists.

Texas “Cow Power” study: key data

Amanda D. Cuéllar and Michael E. Webber, researchers at University of Texas at Austin, conducted a study resulting in a scientific paper, titled “Cow power: the energy and emissions benefits of converting manure to biogas.” The paper was published July 24, 2008. In the U.S., livestock agriculture produces over one billion tons of manure annually. According to the paper’s abstract, most of this manure is disposed of in lagoons or stored outdoors to decompose. Such disposal methods emit methane and nitrous oxide, two important greenhouse gases (GHGs) – harboring 21 and 310 times the global warming potential of carbon dioxide, respectively.

In total, GHG emissions from the agricultural sector in the U.S. amounted to 536 million metric tons (MMT) of carbon dioxide equivalent, or 7% of the total U.S. emissions in 2005; this grand total is calculated to be 7,660 MMT. Of this agricultural contribution, an estimated at 51 to 118 MMT of carbon dioxide equivalent resulted from livestock manure emissions alone. Trends showing this “contribution” increasing from 1990 to 2005. Given this broad range of tonnages, an average of 84.5 MMT of methane should be assigned to livestock. This value becomes the starting point for allocating GHG responsibility to various classes of livestock and their waste.

How much methane gas comes from a certain amount of manure?

The yield for anaerobic methane digestion generally falls in the range of 3 to 8 standard cubic feet of biogas per pound of dry manure. The biogas usually contains 60-70% methane, 30-40% carbon dioxide, and 1-2% hydrogen sulfide; there are also minute amounts of other carbon-centered gases. Actual biogas yield depends on how long the manure is allowed to digest, type of manure, and type of feed given to the animals.

Cuéllar and Webber calculated what would be the potential energy yield in BTUs if all the livestock manure in the U.S. were to be converted into biogas through anaerobic digestion. There is a perfect correlation between pounds of dry manure and potential biogas combustible energy, although there is obviously a range of values for such energy yield. Similarly there is a perfect correlation between pounds of dry manure and potential GHG emissions.

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Greenhouse gas worries are for real

Dairy manure slurry, despite mechanical agitation, is very anaerobic (oxygen-free). Anaerobic manure decomposition produces huge amounts of methane. Although methane, produced by anaerobic decomposition of dairy manure, can be captured and put to productive use as a fuel, most of the gas currently ends up in the atmosphere.

Animal waste science in India have observed the MCF in a dry form, produces insignificant amounts of methane. Current-</p>
Methane-producing bacteria: ancient life form

According to a U.S. Department of Energy publication, the same types of anaerobic bacteria that produce natural gas (the fossil fuel formed eons ago deep in the earth) also produce manure today. They are called methanogenic bacteria. These anaerobic bacteria are some of the oldest forms of life on earth. They evolved even before the photosynthesis of green plants released large quantities of oxygen into the atmosphere. Anaerobic bacteria digest organic material in the absence of oxygen and produce biogas as a waste product. Aerobic decomposition (composting) requires large amounts of oxygen, producing heat.

Methanogenic bacteria are a very diverse group of bacteria, in terms of structure and molecular traits. Detailed studies on their intermediary metabolism have been limited to just two species, Methanobrevibacter smithii and M. barkeri. Methane makes up about 50% of landfill gas, and is the more carbon dioxide than methane would be formed.

Each pound of methane, when burned, yields 2.75 pounds of carbon dioxide.

A closer look at methane combustion

Now let’s look at methane combustion. The chemical reaction involved in burning methane is quite simple: one methane molecule (CH4) combines with two oxygen molecules (O2) to produce water vapor; total of molecular weights remains at 80 pounds (16+64 = 80). Therefore, with these proportions, burning 100 pounds of methane yields 275 pounds of carbon dioxide.

Methane is one of the most important reactions characteristic of anaerobic processes. Production of methane can be used as a test for the anaerobic biodegradability of a substance. Methane is a short-lived greenhouse gas (GHG) with an atmospheric lifetime of approximately 12 years, compared to over 100 years for carbon dioxide.

EPA should measure methane in the air directly over liquid storage on a weekly basis, and do the same over properly aered compost piles. Compost piles thus oxygenated do emit some CO2, but essentially no methane. Compost also presents minerals to the soil in a much more usable form than does liquid manure. Colorless and heavier than air, at high concentrations, this gas may present a health threat.

The economically optimum throughput of manure through the electricity-generating digester is higher than what would be needed for complete digestion. Also, the digester does nothing to the sulfur content of the manure, and actually shifts the nitrogen to a more highly volatile form. Because the digester operates under anaerobic conditions, the discharge from it can be quite odiferous.

How bad is the hydrogen sulfide problem?

Cooperstown Holsteins, Inc. has a dormant anaerobic digester system, called a Metha-Stor. Located just outside Cooperstown, New York, this dairy with 350 cows (plus heifers), is managed by Jennifer Huntington and her partner Eric Watson. I remember when the Metha-Stor was built and supplied natu- ral gas to heat the nearby Otsego County nursing home, located only about two hundred yards away. “Metha-Stor” is the registered product name assigned by the A.O. Smith Corporation to their methane digester. Several months ago, Eric gave me a tour of the methane digester facility, including the cattle operation that supported it. He explained how it once worked, and why it isn’t working any more. The Metha-Stor and accompanying Slurrystore were built in 1984. Presently the Metha-Stor is only functioning as an intermediate storage prior to the liquid manure being pumped to the Slurrystore. The piping to handle the methane is still in place, and is clearly labeled “natural gas.” This piping goes from the Metha-Stor to a large canister which contains a filtration system, which is called a hydrogen sulfide (H2S) scrubber. This part of the methane digestion system has not been used since 2002, because the Metha-Stor just leaked too much after 18 years.

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tended the arrangement; the leakage posed serious liability concerns.
So the Huntthongs next used their biogas exclusively on the farm, powering a 65 kilowatt generator. The biogas had substituted well for the gasoline which originally fed the generator’s engine. Several years ago New York State mandated that utilities must buy back electric power generated by electric customers. This way farmers generated both electricity and income for Cooperstown Holsteins. This utilization ended in 2002, when the walls of the Metha-Stor leaked even more under pressure from the corrosive gases. Then the structure became solely an intermediate storage unit for the slurry. Erich said that the structure has two layers with foam insulation sandwiched between them (think of an Ore cookie). This means that repairing the leaks is infinitely more complicated than patching up other Harvestore products. Repairing (basically re-building) the old Metha-Stor, as well as replacing some aged equipment, would cost about $100,000.

On most farms, on-lagoon concentrations of hydrogen sulfide tended to be significantly higher than ammonia concentrations observed at the same time. Conversely, near-lagoon concentrations of ammonia tended to be significantly higher than the hydrogen sulfide concentrations at the same location. Elevated near-lagoon ammonia concentrations tended to be somewhat evenly distributed across the downwind edge, implying a general surface/air exchange.

Canadians comment on composting…

... a dramatic change from anaerobic digesting

On its Web site, the Composting Council of Canada states that composting is an important way to recycle. It is estimated that about 45% of all waste produced could be composted. Composting not only helps to reduce the amount of waste going to landfills, it helps reduce landfill-generated methane emissions. If disposed in landfills, this methane is released into the atmosphere and contributes to the greenhouse effect. Landfill sites account for about 38% of Canada’s total methane emissions.

If carried out properly, composting does not produce methane, although it will produce carbon dioxide because it is an aerobic process. Although composting does not generate energy as a by-product of the process like anaerobic digestion, composting does help to reduce the amount of GHG emissions. Compost is also a valuable soil amendment which can improve the fertility and texture of the soil.

Jack Lazar, a bedding pack aficionado

Jack Lazar is a man who has devoted much of his life to the business of feeding cattle. Lazar, a former dairy farmer, is a leading expert in the field of livestock bedding. He is known for his understanding of the benefits of using bedding materials that are sustainable and economically viable. Lazar has been involved in the livestock industry for over 40 years, and has a deep understanding of how to manage cattle waste.

What to do about livestock-induced GHGs

In the unlikely opinion of New York City’s Greenhouse Gas Emissions Council (of which I am not a member) the least agricultural practice we have, the fewer GHGs there will be. Just where all their supporting data came from remains an unanswered question. There were about 20 “experts” in this think tank, who appeared to have essentially no farm savvy to balance out their opinions. I was a member of the committee that met in New York City, and I can say that almost no one of the so-called experts had any knowledge of farming or animal feeding operations.

On the other side, there are experts from Cornell University, under the mentorship of Monsanto lackey Prof. Dale Bauman, who can prove that the use of Posilac on dairy cattle lowers GHGs. The logic here is that improved production per cow means our country’s milk needs can be met with fewer cows. Cows give off methane based on body mass, so more milk from fewer cows means less methane. No argument here. A fact which is conveniently ignored is that the methane that cows produce is the by-product of the rumen fermentation process. This process, which is essential for cows to digest their food, produces a gaseous effluent that is rich in methane.

Conclusion

Here’s my recommendation: extracting from the University of Texas data, we glean that each cow on average is responsible for 1,500 lbs of GHG per year. We show that in these GHGs, which are from the liquid manure facilities handling the waste from the cows, that 75% of the emissions are in the form of CH4. The remaining 25% is the gaseous effluent of manure going to landfills. A single cow produces about 1.933 megawatt-hours of energy per year back at a rate of $.117 per kWh, and the resulting return on equity (ROE) was 0.504% (less than 1%). He also showed that if power costs increased so that buy-back rate became $2.35 per kWh, then ROE would increase to 12.219%. Clearly the prospect of energy sales as an income source must be closely analyzed.

Author's closing comments and recommendations

I believe that policy-influencing people have more authority than good facts. Here is one more doubt that is as great as the others. Posilac on dairy cattle lowers GHGs. This change alone would achieve the 25% livestock-based GHG reduction (or 2.1 billion metric tons of CO2 equivalent). Carbon dioxide – a bad GHG – is a major by-product of methane combustion.

On the other side of the fence, we find complete ignorance in the environmental “logic” and demands by certain urbanites who mistakenly blame livestock for one-third of the globe’s GHG problems. My contention, after reviewing the facts: livestock manure, when properly managed through composting, can dramatically help the U.S. dairy industry reduce GHG output and comply with tougher environmental dictates. How we manage our livestock and wastes is the critical issue in whether dairy industries are environmentally sound or downright wrong.

Greenhouse gas (GHG) Glossary & Notes

GHG: greenhouse gas

University of Texas: The “Cow Power” paper can be read in its entirety at: http://www.iop.org/EJ/article/1748-9326/3/3/030402/ehr_8_3_030402.html

India research Web site:

www.methaneefficiency.org/expo/expo/postexo/ag-india

Manure dry matters: these range from 15% to 25% in fresh manure (straight out of the cow), to 5% in liquid systems; the lowest dry matters are found in uncovered, outdoor lagoons

Wisconsin research Web site:

http://www.wisconsin.edu/agriculture/land/water/odor/index.jsp

Glenn Rogers: Contact Glenn Rogers at: Glenn.Rogers@uvm.edu

Impertinent covers cited in the Wisconsin study are made out of rugged, synthetic materials; lasts up to fifteen years. These covers are supported by the milking herd management system by a roller structure.

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