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.

Dairy animal waste management can be either an opportunity or a failure for dairy, in a future environment that closely scrutinizes GHG production. Generating 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 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 short-lived 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, GHGs cause global warming by trapping infra-red radiation (IRR). On a weight basis, each unit of methane is 21 times as effective as carbon dioxide in preventing the escape of IRR from the earth's atmosphere. Something about the molecular structure of methane repels IRR back toward the earth's surface significantly more so than does CO2.

Liquid livestock manure storage systems very likely maximize the retention of nitrogen and mineral elements leaving the north end of a south-bound cow. But we must accept that the anaerobic environment in these liquid manure systems seriously heightens the GHG threat. As we consider the potential benefit of methane used for fuel, containing the methane emissions becomes more of an ecological concern than one of economics.

Increased national awareness of GHGs' impact on climate change means more focus on livestock-produced GHGs. But the total mass of wild animal bioforms and humans in our country certainly would exceed the total mass of domestic livestock bioforms which the Enviromental Protection Agency (EPA) proposes to regulate. The animals themselves, wild and domestic, and whatever gaseous carbon effluents they excrete, aren't the problem. The method of how we store livestock manure is the big culprit. Liquid manure ponds, lagoons, etc., are particularly guilty as discharged – releasing huge quantities of methane into the atmosphere.

According to the EPA, liquid manure management systems – ponds, anaerobic lagoons, and holding tanks – create oxygen-free environments that promote methane production. However, manure deposited on fields and pastures, or otherwise handled in a dry form, produces insignificant amounts of methane. Currently, livestock waste contributes about eight percent of human-related methane emissions in the U.S. Given the trend toward larger dairy farms, liquid manure management is expected to increase, and with it the GHG impact of methane.

Manure-to-Methane Conversion Factor

How much methane can be generated from carbon-centered material depends on several factors, the two most important being "digestible" volatile solids and methane conversion factor. After the mineral fraction of manure is factored out (commonly called ash, normally about 10% of the total dry matter), what's left of the dry matter is volatile solid (VS). VS is a solid that can easily tranform into a gas.

About half of the VS is digestible and could be made into methane; the remainder of the VS is "indigestible" and never will become methane. The digestible VS consists largely of carbohydrate, fat, and protein. Methane conversion factor (MCF) is determined by the form of manure and its storage system.

Animal science researchers in India have observed the MCF in a dry lot to average 2%. Solid storage of manure shows MCF of 5%, and an uncovered anaerobic lagoon has an average MCF of 80%; methane digesters also have an 80% MCF. Given that VS normally runs about 40% carbon, also that VS is about half digestible, and methane is exactly 75% carbon, we would expect 100 pounds of manure solids from an uncovered anaerobic lagoon to yield 19.2 pounds of methane. In this study no mention was made of compost, because in India it is generally accepted that compost produces no significant methane.

Table 1: Annual energy, and/or greenhouse gas, available In U.S from manure sorted by animal category

	Units *	BTU/yr**	% BTU/GHG	MMT/yrGHGs
Fattened Cattle	9.6	89.9	9.7	8.2
Milk Cows	12.3	92.1	10	8.4
Other* **	58.8	497	53.5	45.4
Swine	8.5	124	13.4	11.2
Poultry	6.1	125	13.4	11.3
Total	**95.3**	**928**	**100**	**84.5**

*Animal Units ** million BTUs ***beef & dairy, mostly young, half on pasture
Data source: Univ. of Texas Author calculated MMT/yrGHGs column.

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.

Approximately a thousand people attended that 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, storage, preparation, sale and disposal of food, and 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 GHGs 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 digesters 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. Therefore it is mathematically sound to calculate GHG pollution threat backwards from potential energy yield in BTUs. Thus as shown Table 1 (above), I was able to estimate the amount of GHG emissions, and tabulate such along with the researchers' data. (Note: an animal unit is arbitrarily defined as 1,000 pounds; e.g., 250 four-pound laying hens would comprise one animal unit.):

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. Climatologists estimate that methane's greenhouse gas impact (the popular phrase is carbon footprint) is 21 times more harmful than carbon dioxide. **Increased storage of livestock manure in lagoons and holding ponds has significantly worsened dairy's negative environmental impact.**

EPA data show that CO2 equivalents emitted by U.S. livestock manure storage systems, and heavily weighted by methane, have increased from 31.0 terragrams to 41.4 terragrams, from 1990 to 2006. A "terragram" is one thou-

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e Digesters … Green or Dirty Brown?

sand billion grams. Expressed in English, this means that annual greenhouse gas emissions from livestock manure storage, for each of 300 million Americans, has increased from 225 pounds to 300 pounds of CO_2 equivalents. These data align reasonably well with the previously cited University of Texas findings.

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 methane 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, *Methanobacterium thermoautotronhicum* and *M. barker*. Methane makes up about 50% of landfill gas, and is the most reduced organic molecule. No further conversions to simpler organic molecules are possible once methane has been produced. Let us look at the simple conversion reaction producing methane:

Carbohydrates, and even oils, are oxidized to become acetate (CH_3COO). Water, in the absence of oxygen (this environment **is** anaerobic), reacts with the acetate to form methane (CH_4) and carbonate (HCO_3). If more oxygen were present, much 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 (CH_4) combines with two oxygen couplets (two of O_2) plus heat. The burning is obviously conducted in an aerobic environment. The end products are one carbon dioxide molecule (CO_2) and two water molecules (H_2O). Each pound of methane, when burned, yields 2.75 pounds of carbon dioxide. But this CO_2 still ends up in the atmosphere, unless it is pressurized into water (or metabolized by a plant).

Here's the chemistry: The relative molecular weights of the compounds involved indicates that 16 pounds of methane reacts with 64 pounds of oxygen. The end products of combustion are 44 pounds of carbon dioxide and 36 pounds of water vapor; total of molecular weights remains at 80 pounds (16+64 = 44+36). Therefore, with these proportions, burning 100 pounds of methane yields 275 pounds of carbon dioxide.

Flaring 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 windless day, and do the same over properly aerated compost piles. Compost piles thus oxygenated do emit some CO_2, but essentially no methane. Compost also presents minerals to the soil in a much more usable form than does liquid manure. The presence of methane should also be assessed in the air over meadows and stubble ground where manure is spread daily. The air should be tested for methane immediately after liquid manure is spread on a field. Then the Agency would be able to properly evaluate GHG emission "blame."

Wisconsin study: Ammonia and hydrogen sulfide are nasal nuisances

The Dairy and Livestock Air Emission Project was a joint effort with the Wisconsin Department of Natural Resources (DNR), partially funded through a USDA Conservation Innovation Grant or CIG. The project was a three-year, $1.6 million demonstration of current technologies that focused on control of odor and concentrations of ammonia and hydrogen sulfide from agricultural operations. Different methods of odor containment were employed at each of six different locations in Wisconsin; the project was completed in September 2009. Two of the farms had anaerobic methane digesters.

It was shown that the impermeable covers were highly effective at controlling odors (100% reduction), as well as NH_3 and H_2S concentrations. The permeable cover was fairly effective at controlling odors (70% reduction) and reducing NH_3 and H_2S concentrations. The combination of solid separation and aeration reduced odors, however not to a significant degree (25% reduction), while H_2S concentrations were reduced and NH_3 concentrations actually increased. Anaerobic digesters had mixed results for odor control, as well as for their effect on NH_3 and H_2S concentrations. One digester reduced odors slightly (15% reduction), while another digester increased odors by 15%, when compared to a similar non-digester farm. H_2S concentrations were reduced on both digester farms, however ammonia concentrations were elevated.

Ammonia was collected onto carbon beads, which were treated with sulfuric acid. The ammonia reacted with the sulfuric acid to form a chemical bond on the tube containing the beads. The chemical bond was then reversed in the lab. The resulting solution was then measured using ion chromatography. The chemical nature of the absorption makes these samples more stable to external conditions than the hydrogen sulfide samples.

An explanation for this might be that although a digester breaks down the organic compounds in manure, it does so only partially, based on residence time.

USDA is proposing that all dairy farmers with 1,000 or more milk cows install methane generators. BEWARE!

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.

One digester's owner recognized that odors continued to impact his neighbors after the installation of the anaerobic system. Being an innovative manager, he engineered a gas treatment apparatus to address this matter. This system used a blower to capture the fugitive emissions from the digester outlet and send them to a tank where they are bubbled through water. This causes the H_2S to be absorbed by the water, forming a weak acid solution that is then combined with other wastes in the storage lagoon. Although fairly simple in design, this system is very effective at controlling gaseous emissions from the digester. He has made other modifications as well, such as installing a more reliable gas flare, similar to the kind used at municipal land fills.

Raw data indicate that odors may be somewhat increased by the digesters, rather than being decreased as was initially expected. Daytime ammonia concentrations may be higher than those observed during the night, while the reverse may be true for hydrogen sulfide, which, concentrated, is an extremely toxic gas.

Hydrogen sulfide levels may increase a thousand-fold during the agitation of manure. Colorless and heavier than air, at high concentrations, this gas may cause death within minutes. At lower concentrations it can irritate and damage the eyes and respiratory tract. While H_2S is commonly known for its rotten egg odor, the odor is not detectable by the human sense of smell at higher concentrations. There may be very little warning when a relatively benign situation has changed into a potentially hazardous one.

Occupational exposure standards, established by OSHA, for hydrogen sulfide are 20 parts per million (ppm) averaged over a typical 8-hour day (also not to exceed 50 ppm over any 10 minute period) which is significantly higher than those established by the Wisconsin Department of Natural Resources for general ambient air (0.24 ppm). Occupational standards are higher because it is assumed that these exposures will be affecting healthy individuals working typical work days (40 hours per week) in workplaces, while general ambient air concentrations can represent year round exposure levels.

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 natural 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 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 (H_2S) 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.

Cooperstown Holsteins sold biogas to heat the nearby nursing home from 1984 to 1987, a function cut short when leaks developed in the roof of the Metha-Stor, due to H_2S corrosion. Metha-Stor was a brand new product in 1984, and not all the kinks were ironed out. Even though the biogas leakage was over two hundred yards away from the nursing facility, Otsego County officials

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terminated the arrangement; the leakage posed serious liability concerns.

So the Huntingtons 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 the methane digester 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. Eric said that the structure has two layers with foam insulation sandwiched between them (think of an Oreo cookie). This means that repairing the leaks is infinitely more complicated than patching up other Harvestore products. Repairing (basically rebuilding) 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 collected at the same locations. 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, these materials decompose anaerobically and produce methane. 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 as such does not directly save energy, it can greatly reduce the amount of GHG emissions. Compost is also a valuable soil amendment which can improve the texture and fertility of the soil.

Jack Lazor, a bedding pack aficionado

Just below the Canadian border in northeast Vermont is Butterworks Farm, owned and operated by Jack and Anne Lazor. They have been farming organically with Jerseys for 35 years. They market all of their milk as yogurt, labeled with the Butterworks Farm brand, and produced only on their farm. Theirs is a closed herd, as no replacement cows have ever been purchased; every one of their 45 Jersey cows was born on their farm. The entire herd is housed in a 60' by 120' hoop barn. The barn's floor is covered with chopped straw and low quality hay. During non-pasture season the animals' manure gets trodden into the plant material. Periodically, this bedding/manure pack is removed and piled in rows near the barn. These rows are turned so as to aerate them and enhance the bacterial degradation of waste materials.

There is carbon dioxide released from this microbial activity, but basically no CH_4 or H_2S. This chopped up, aerated, material, though not officially defined as compost, is the backbone of Lazors' crop fertility program. Jack did say that when he turns the rows of bedding pack, there is often an ammonia smell. I suggested that he broadcast gypsum or rock phosphate, just before chopping new straw or hay. Either or both of these mined materials will chemically bind the ammonia fraction of the manure and eliminate any odors. Jack believes that liquid manure adds to GHG pollution, but there's also another problem… nutritional: the potassium in liquid manure is usually in a form, which, when spread on a hay meadow, produces hays which tend to knock a dry cow's diet out of balance. Disrupted dry cow diets often result in milk fevers.

What to do about livestock-induced GHGs?

In the unlearned opinion of New York City's Greenhouse Gas Emissions conferees (and the Manhattan Borough President), the less animal agriculture 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 "book smarts." Fortunately, a member from Heifer International was present at the meeting. He successfully injected an opinion that increased grazing of ruminants has not been shown to worsen GHG levels and global warming. Apparently the 20 deep thinkers didn't want to be confused with facts.

On the other side, there are experts from Cornell University, under the mentoring of Monsanto lackey Prof. Dale Bauman, who can prove that 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 resulting larger cow operations (by definition, concentrated animal feeding operations, or CAFOs) rely increasingly on liquid manure management. Liquid manure systems, which are very anaerobic, are shown to release more methane than daily spreading, composting, or, for that matter, the emissions of the cows that made the manure. Total GHGs on the planet have been shown to increase by one-third between 1990 and 2006 (EPA data again). The issue here is not so much how many livestock there are, but how their manure is managed.

There is little question that the University of Texas study's data totally trumps ill-informed Manhattan Borough President Stringer's livestock GHG presuppositions (Texas does boast more livestock than any other state). Given that, and taking the Cuéllar and Webber data a couple steps further, it's easy to prove that the U.S. dairy industry is only responsible for one nine-hundredth of the total U.S. GHG output (8.4 MMT versus 7660 MMT)!

What about the energy value of biogas?

Glenn Rogers, regional farm management specialist for University of Vermont Cooperative Extension, has conducted farm business analyses on three methane digesters over the last six years. During 2008 a total of 1,212 cows produced manure that was processed through methane digesters in this study. Basically, the three digesters ran almost non-stop or 8,760 hours for the year; scheduling preventive maintenance proved to be a challenge. A total of 1,933 megawatt-hours was produced. Total income includes the sale of electricity back to the rural electric co-op, sale of bedding (fibrous dry waste) to their own farms (as well as other farms); big expenses included maintenance and repairs, labor; lesser expenses were fuel, insurance, office functions.

(Editor's note: Three digesters were removed from Roger's study during the period of the analysis.)

Rogers showed that total investment averaged about $2 million per farm, and that grant money covered about 35% of that. During 2008 the energy buy-back was 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 $.235 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. There is little doubt that as livestock manure is increasingly managed in liquid form, the carbon footprint of these animal industries increases greatly. The solution to the problem, however large it happens to be, may not be easy to implement, but it is simple. I'll back this statement up with the words of Professor E. Ann Clark (Guelph University, Ontario, Canada), which closed her presentation last July at the annual meeting of the Northeast Branch of the American Society for Agronomy, held in Portland, Maine. Quoting Prof. Clark:

"Grass is the forgiveness of nature. This means that grass agriculture compensates for the higher environmental impact of annual row crops. The more we can bring back grazing and permanent covers, the more we will be able to reduce the greenhouse gases caused by livestock agriculture."

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 her waste (as well as from the cow herself), that this gaseous effluent is about 2/3 methane and 1/3 carbon dioxide. Since methane is about 21 times as potent a GHG as CO_2, if that animal's manure were managed properly as compost, then her carbon footprint would be reduced by 93% [100 CO_2 versus (66 x 21 CO_2 + 34 CO_2)], or about 1,395 pounds CO_2 equivalent per year.

Let's take this one step further: if the manure from 3.3 million cows (approximately 4 million animal units) of the country's combined beef feedlot and dairy cows were managed as compost rather than liquid, a great benefit would occur. This change alone would achieve the 25% livestock-based GHG reduction (or 2.1 MMT) proposed by Obama and Vilsack. But let's be gentle about implementing this change: just ask these CAFOs collectively to convert to composting at a rate of 330,000 animal units per year over the next 10 years. With any (or lots of) luck at some point, could this change result in no more liquid manure?

This recently-announced GHG abatement program by the federal government is patently wrong. Producing methane from livestock manure and then burning that methane serves to worsen GHG problems. 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 handle livestock manure and wastes is the critical issue in whether dairy industry practices 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/1748-9326/3/3/034002/erl8_3_034002.html

India research Web site:
www.methanetomarkets.org/expo/docs/postexpo/ag-india

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

Wisconsin research Web site:
http://www.datcp.state.wi.us/arm/agriculture/land-water/odor/index.jsp

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

Impermeable covers cited in the Wisconsin study are made out of rugged, synthetic, materials that last up to fifteen years. These covers are supported over the liquid manure storage system by a rafter structure.

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