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MATERIAL WORLD

Down on the Farm, an Endless Cycle of Waste

By [HENRY FOUNTAIN](#)

GUSTINE, Tex. — Day and night, a huge contraption prowls the grounds at Frank Volleman's dairy in Central Texas. It has a 3,000-gallon tank, a heavy-duty vacuum pump and hoses and, underneath, adjustable blades that scrape the surface as it passes along.

In function it is something like a Zamboni, but one that has crossed over to the dark side. This is no hockey rink, and it's not loose ice being scraped up. It's cow manure.

Lots of cow manure. A typical lactating Holstein produces about 150 pounds of waste — by weight, about two-thirds wet feces, one-third urine — each day. Mr. Volleman has 3,000 lactating Holsteins and another 1,000 that are temporarily "dry." Do the math: his Wildcat Dairy produces about 200 million pounds of manure every year.

Proper handling of this material is one of the most important tasks faced by a dairy operator, or by a cattle feedlot owner, hog producer or other farmer with large numbers of livestock. Manure has to be handled in an environmentally acceptable way and at an acceptable cost. In most cases, that means using it, fresh or composted, as fertilizer. "It's a great resource, if used properly," said Saqib Mukhtar, an associate professor of biological and agricultural engineering at [Texas A & M University](#) and an expert on what is politely called manure management.

But as the increasing incidence of environmental and health problems linked to agriculture makes clear, when manure is mismanaged the nutrients in it can foul streams, lakes and aquifers; the pathogens in it can contaminate food products; and the gases it produces, including ammonia, methane and bad-smelling volatile compounds, can upset neighbors and pollute the atmosphere.

Even with best practices, manure can cause environmental headaches. So researchers are working on ways to improve its handling, to modify the nutrients in it and to develop alternative uses.

Mr. Volleman, who came to Texas from his native Luxembourg 16 years ago, takes pride in his operation, which produces about 25,000 gallons of milk a day. "It's all about keeping it clean, keeping it comfortable and producing high quality milk," he said, adding that what is good for his cows is good for him. "They're writing my paycheck."

Dairies differ from feedlots, poultry operations and hog farms in how they handle manure. At a feedlot, for example, manure is often collected only once every six months, after the thousands of fattened cattle have been shipped out. Dairy operators seem like neatniks by comparison, but even among dairies, manure

management varies according to location, climate, regulations and other factors.

At a large operation like Mr. Volleman's, it is the inexorability of excrement, as much as the sheer volume, that defines the waste-handling process. A cow's digestive system, with its series of forestomachs, is built to handle lots of roughage. And you cannot turn it off.

So among the 40 employees at Wildcat Dairy are some whose main task is to handle the manure, 24 hours a day. They collect it from the huge open-sided barns, which house up to 1,200 cows each. The animals bed down in sand, but there is a concrete alley running the length of each barn for food and others for excrement.

While the cows are at the rotary parlor — a stainless-steel merry-go-round of milking stalls that the Holsteins ride every eight hours around the clock — a worker on a tractor tows the tank-pump contraption up those manure alleys. The worker hops off the tractor as needed to rake solids in the bedding area into the alleys for collection.

When the tank is about half full, the worker drives it to a nearby patch of dirt, opens a valve and spreads — sprays, really — the manure out to dry. Twice a week, the solids are scraped into windrows and then spread on fields as fertilizer.

Even dried, manure contains a lot of water, so it is not economical to truck it very far — beyond about 10 miles, it is cheaper for a farmer to buy inorganic fertilizer. Some dairy producers compost their manure, making it more valuable as fertilizer, but composting costs time and money.

Mr. Volleman's manure is spread only on his fields and those of nearby farmers. "We bring the manure to their fields, they spread it out to grow crops, we bring the crops back to feed the cows," he said. "So it's kind of a circle — a closed circle."

The liquids in the manure are part of a closed circle as well. Everything at the dairy is sited with gravity in mind, so that all liquids — the runoff from the drying area, wet manure left behind in the alleys, wastewater from the milking parlor and rainwater — drain into the first of three interconnected lagoons that are lined with compacted clay.

The first lagoon is bubbly and dark, with anaerobic bacteria digesting the organic matter to reduce odor. By the third lagoon, the water is clear and dilute enough to be pumped to irrigation equipment on Mr. Volleman's fields.

But the margin for error in handling both the solids and liquids is thin.

Farmers must plan where and when they spread dried manure, both to avoid odor complaints from downwind neighbors and to avoid overapplying nutrients that may run off in a rainstorm. "It's like any other business," Dr. Mukhtar said. "If you're not keeping track of where your nutrients are going, you may be reapplying those nutrients on the same piece of land. That's more than the plants can take and the soil can hold."

One problem, said Robert T. Burns, a professor in the department of agricultural and biosystems engineering at [Iowa State University](http://www.iastate.edu), is that manure typically has more phosphorous than needed. "Manure is an

unbalanced fertilizer from the plant's view," Dr. Burns said.

Diet modification can help, to some extent. Phosphorous is added to dairy feed as a supplement, and research has shown that it tends to be added in excess, said William P. Weiss, a professor in the animal sciences department at [Ohio State University](#). "You can get good milk and good health at much lower levels," Dr. Weiss said. "And every gram less they feed is a gram less excreted."

Nitrogen, on the other hand, comes from protein, and a lactating cow needs to consume a lot of protein. "Decrease it a bit, and then milk production falls off," Dr. Weiss said.

With nitrogen, the problem is usually not that there is too much, but that much of it is eventually lost from the manure in the form of gaseous ammonia. The bacteria in feces contain an enzyme, urease, that breaks down urea in urine into carbon dioxide and ammonia. As with phosphorous, diet can affect the amount of nitrogen retained in the manure. As corn-based ethanol production has increased in the United States, many dairies and feedlots now give their animals a large amount of so-called distillers' grains, the waste corn after fermentation, which are plentiful and cheap. A recent study of feedlots in the Texas Panhandle, by scientists with the [United States Department of Agriculture](#), showed that feeding a diet high in distillers' grains produced significantly higher ammonia emissions from the manure.

Emissions problems can also be reduced by changing how the manure is applied. Tilling the soil immediately after application of dried manure can help reduce odors, Dr. Mukhtar said. And if manure is directly injected into the soil in slurry form, Dr. Burns said, the ammonia can better bind with the soil. Currently in Iowa, a major hog-producing state, about 80 percent of hog manure is injected.

When it comes to the liquid end of things, there are delicate balances to be maintained as well.

Regulations vary by state, but in Texas, manure lagoons have to be big enough to handle a severe rainstorm of the type that occurs, on average, only once every quarter-century. The danger is that an overflow from a lagoon, with its high concentration of organic matter and nutrients, could eventually reach a creek or some other body of water and kill fish.

Mr. Volleman points out that his lagoons, which have a total capacity of 120 acre-feet, or about 40 million gallons, are 20 percent larger than required. "We've never overflowed," he said. And the dairy has berms around its 80 acres to minimize the risk if an overflow occurred.

But not every dairy operator is scrupulous. "There are bad actors in every walk of life," Dr. Mukhtar said. "Progressive dairy producers will be the first ones to say, 'Let's nail their tails to the wall.'"

Problems can arise if a dairy adds cows without increasing lagoon capacity, or if a farmer is not careful about controlling the inorganic solids that enter them. Mr. Volleman, for example, used to flush his barns with water instead of vacuuming them. But he found that there was too much sand and other solids entering the lagoons.

Controlling solids is crucial, said Dr. Mukhtar, who has evaluated other methods for doing so, including a "weeping wall" system, manure storage areas with porous walls that filter the solids from the liquids.

Even when solids are controlled, Dr. Mukhtar said, sludge builds up in a lagoon and eventually has to be removed. Neglecting to do so results in less water, and less bacteria, in the mix. “All of a sudden this is not a properly functioning lagoon,” he said. “That’s where we have odor issues.”

Another option is to digest the manure in a tank (or, alternatively, put a cover over a lagoon) to produce gas that can be burned for heat or electricity. Another approach, gasification, heats the manure to collect combustible gases.

Those options, however, are expensive. Even in a good economy, a dairy producer may be reluctant to add costs. And the industry is currently suffering — milk prices are low, producers are losing money and some are going out of business. “Given these times,” Dr. Mukhtar said, “there is really not a whole lot of incentive to do all that.”

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