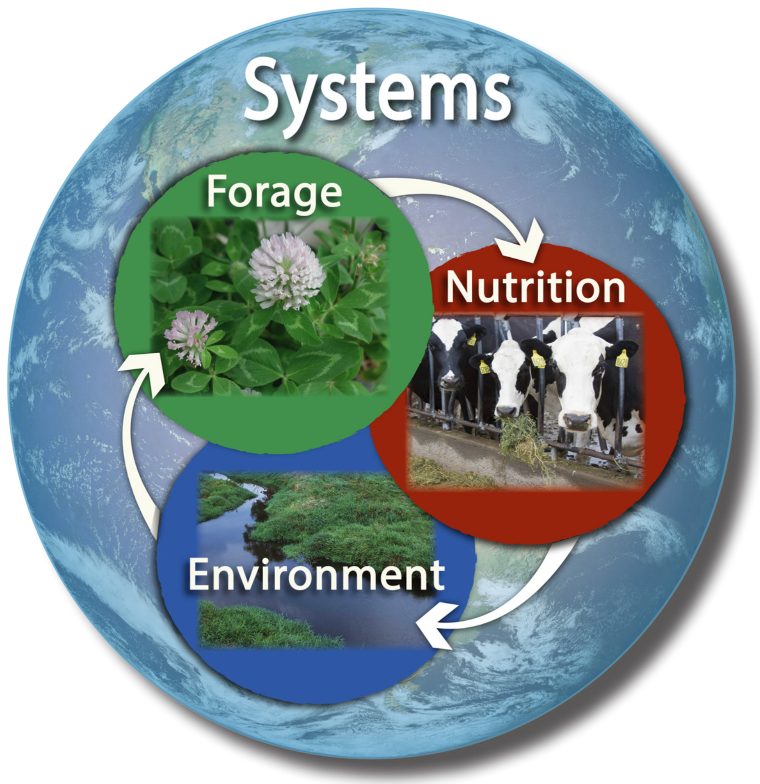
United States Department of Agriculture

U.S. Dairy Forage Research Center

In the News



April to August, 2016

Manure after alfalfa: Consider the options

by Bill Jokela

APPLYING manure immediately after alfalfa harvest opens up windows of time for manure application not available with most annual crops, and it expands the acreage base for nutrient management plan requirements. In addition, alfalfa can benefit from the potassium, phosphorus, sulfur, and micronutrients in manure.

When it comes to nitrogen (N), it seems counterintuitive to apply manure to alfalfa and other nitrogen-fixing legumes. But here the benefit can be to the environment because applying N actually reduces the amount of symbiotic N fixation, thus reducing the risk of nitrate leaching from the applied manure.

Application of liquid manure on established stands of alfalfa has shown mixed results. Topdressed slurry resulted in higher, lower or no change to harvested yield in research from Minnesota, Wisconsin, and Maryland. Probably the most comprehensive study was one in Ontario where liquid dairy manure was band-applied twice annually to 49 alfalfa cultivars for three years. Average alfalfa yields rose 14 percent with manure compared to the no-manure control, with some varieties showing much larger yield responses.

Broadcast alternatives

Surface broadcast is the dominant method of manure application for alfalfa and other perennial forages in the U.S. Beyond soil compaction and plant damage, there are other challenges associated with broadcast manure application on alfalfa following a harvest — plant smothering, introduction of pathogens that may contaminate feed, nutrient runoff, and odor or ammonia emissions. However, careful management can minimize these challenges.

So, too, can alternative broadcast application options such as shallow injection, surface banding above the canopy, banding on the soil surface with drag-shoe or trailing-foot, and band application with tine aeration. These methods can reduce challenges associated with broadcast application because manure is applied in narrow bands directly into the soil or on the soil surface, often underneath the crop canopy. Other possible benefits are reduced odor, nutrient runoff and gaseous emissions. Such benefits need to be balanced against the potential for stand or yield loss from soil disturbance and mechanical damage to plants.

There has been only limited research with alternative application methods on alfalfa. In a Saskatchewan study, injection of manure improved alfalfa yields on a low-fertility site but lowered yields on a high-fertility site due to stand damage.

We have completed two years of a three-year study evaluating different methods for applying liquid dairy manure on alfalfa in central Wisconsin. The following treatments were applied to an established alfalfa site: a) control (no manure; fertilizer based on need); b) broadcast liquid dairy manure; c) surface-banded manure; d) aerator/banded manure (AerWay SSD); and e) shallow injection (Yetter Avenger). See photos.

Manure was applied annually after first (2015) or second (2014) harvest with an 1,800-gallon research model spreader. The target manure application rate was 4,000 to 5,000 gallons per acre, but equipment problems in 2014 resulted in an excessive rate that year.

Initial Wisconsin results

Alfalfa yields for individual harvests ranged from 1.0 to 1.5 tons per acre for third cut to over 3.0 tons per acre for first harvest with no significant yield differences in most cases.

There were no significant treatment effects on yields in the first harvest after the August 7, 2014, manure application, nor on the next harvest in June of 2015. This suggests that there was little or no damage to the stand due to manure or mechanical effects. However, yield from shallow injection was significantly lower than most other treatments in the first harvest (July 22) following the 2015 manure application. But the yield effect had disappeared by the next harvest in August.

Ammonia emission was greatly reduced by shallow injection compared to the other methods. Emission of nitrous oxide, a potent greenhouse gas, was increased by manure application but was limited primarily to the few weeks following application. Treatment effects were somewhat variable, but in 2015 nitrous oxide emission was greater from the injection and aerator-band treatments than from broadcast.

In summary, preliminary results from the first two years of this study show minimal effects of manure application on yield compared to the no-manure control (optimum or higher soil test P and K); however, there was some indication of a short-term (one harvest) decrease in yield from the injection treatment. Injection greatly reduced ammonia emission, but there may be a trade-off with increased greenhouse gas emission. •

Aerator/banded manure (Aerway SSD; left) and shallow injection (Yetter Avenger; right) application implements.

BILL JOKELA

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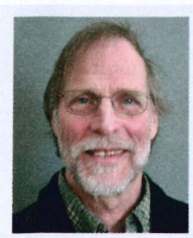

Hoard's Dairyman Intel, May 16, 2016

Manure and water concerns spark study

by Corey Geiger, Managing Editor

Yakima. The Chesapeake Bay. Lake Champlain. The Texas Panhandle and eastern New Mexico. Kewaunee County.

Whether perceived or real, the aforementioned regions have been epicenters for concerns regarding dairy nutrients, mainly manure applied to nearby land.

Each area has a unique story. In the case of Wisconsin's Kewaunee County, an independent three-year study is taking place that involves the University of Wisconsin-Oshkosh's Department of Geology and USDA's Agricultural Research Service (ARS). The entire project is being funded by the Wisconsin Department of Natural Resources (DNR).

Located in the northeast portion of the state, Kewaunee County is home to over 100 cows per square mile, making it one the nation's most densely populated dairy areas. Much of the area's topography includes the Niagara Escarpment that stretches throughout the Great Lakes Region from New York to Wisconsin. While the limestone outcroppings are a beautiful feature, the stone that pushes up through the soil's surface also can be considered a liability. So, too, can the shallow layers of soil found over the limestone bedrock and the rock fissures that can extend deep into the earth. It's these features that have caused some in the community to question whether or not nutrients and bacteria found in manure are making their way into nearby wells.

Earlier this month, Wisconsin DNR Secretary Cathy Stepp shared some preliminary data with the press. The study has been looking at 323 wells in the area. Preliminary results indicate that nitrate levels have been consistent with statewide averages for agricultural areas and those locations without sewers for nearby homes. DNR Secretary Stepp also pointed out that five wells did test positive for E. Coli . . . although the sources have not been pinpointed.

Also this month, salmonella and rotavirus were both found in a subset of Kewaunee County wells during the ongoing study. However, it is too early to pinpoint the contamination found in 11 of the 20 wells, according to a *Milwaukee Journal Sentinel* report on May 4, 2016, by Lee Bergquist.

Those results came from the next part of the study that started this April. Future sampling will take place in July, later this fall, and in the winter, said Mark Borchardt with USDA's Agricultural Research Service. The water samples have been drawn from a randomized sample of Kewaunee-area wells. Those wells were further classified into three groups based on depth to bedrock . . . not depth of well.

Nearby farmers living in the community have been working as a group to discuss and address water quality.

Peninsula Pride Farms is a nonprofit organization that includes 40 farmers in Kewaunee County and its neighbor to the north, Door County. Don Niles serves as president for the group, and an early project included a field day measuring depth of soil to bedrock.

Over the course of the next year, science will reveal more definitive results into the groundwater woes in the Kewaunee County region. While some environmental groups place blame on the cows found in the area, the likely result will be a multiple list of concerns that could also include shallow wells and a comprehensive need for updated septic systems for nearby homes. Also on tap could be updated practices and manure treatment options on managing the area’s unique rock features in the Niagara Escarpment region.

The good news, thanks to folks like Mark Borchardt, is that there will be a science-based answer after this three-year long study.

High-quality or right-quality forage?

Mary Beth Hall for *Progressive Dairyman*

Cows are designed to use forage. It keeps them productive and healthy. Forage quality sets the limits for how much forage we can feed and the ceiling on how well animals can perform. We include as much in rations as we can while making sure nutrient requirements are met and cows are healthy. And everyone knows you can only do this with high-quality forage, right?

But wait a minute ... then why do a lot of dairy farms feed straw to their milking herd? There's no way straw qualifies as high-quality forage. Maybe we need to change the discussion from "high quality" to "right quality" and discuss what we need forages to do.

Forages do two very important things in the ration:

- The digested part of forage provides nutrients to the cow.

- The large particles, the physical form of forage, maintain healthy rumen function.

So for the cows, we need forages that are digestible enough to provide nutrients and have the right physical form. But what happens if the only forage you have is a 25 percent protein, 35 percent neutral detergent fiber (NDF), high-digestibility alfalfa silage? Or a 40 percent starch, 35 percent NDF corn silage? They may be very high quality on the digestibility and composition side, but they won't provide enough fiber to keep the cow healthy. Think of them as the equivalent of an all-cheesecake diet. What forages would you add to keep cows healthy? This is where straw, grass or some higher-fiber forage might come into the ration, even though we'd call them lower-quality.

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When we talk about forage quality, we should probably talk about right quality instead of high quality. Right quality includes how well a feed complements the rest of the ration to meet the cows' needs. It takes into account the need to balance the whole ration.

As we strive toward the right quality of forages for our rations, the forage characteristics we need to consider are physical form, composition, digestibility and amount.

Physical form

Physically effective fiber is key to allowing rations to work well. It describes the physical form of the forage that increases cud chewing, maintains good rumen function and reduces the risk of ruminal acidosis. It can form a mat in the rumen that acts to retain feed particles so they can be fermented by microbes, while the smaller fragments of broken-down fiber may help to move feed and microbes out of the rumen. Two keys to a physically effective fiber source include:

- *Particle size:* Larger particles encourage more rumination than smaller particles ... but only if the cows eat them. Particles 1 to 2 inches long in a moist, hard-to-sort ration work well.

Continued on page 78

Table 1

Minimum ration NDF percent	Minimum forage NDF percent	Maximum ration NFC percent
25	19	44
27	18	42
29	17	4
31	16	38
33	15	36

Percentages of total ration NDF, forage NDF and non-fiber carbohydrate (NFC) as a percentage of ration dry matter recommended for lactating dairy cows. Source: NRC, 2001.

Figure 1 Fecal particle size

Particles from two samples of rinsed manure from two animals provided with the same TMR. The sample on the left was in a good-looking cow pie, the one on the right was in a pile of bubbly diarrhea. The very large particles represent feed that escaped the rumen before it was sufficiently ruminated and digested.

Figure 2 Using NDF content of forages to make a rough estimate of how much of a given forage can be included in a ration

	Forage NDF	Maximum in diet %
Straw	80%	26%
Barley silage	55%	38%
Alfalfa silage	45%	47%
50:50 (Barley:alfalfa)	50%	42%
Corn silage	45%	47%

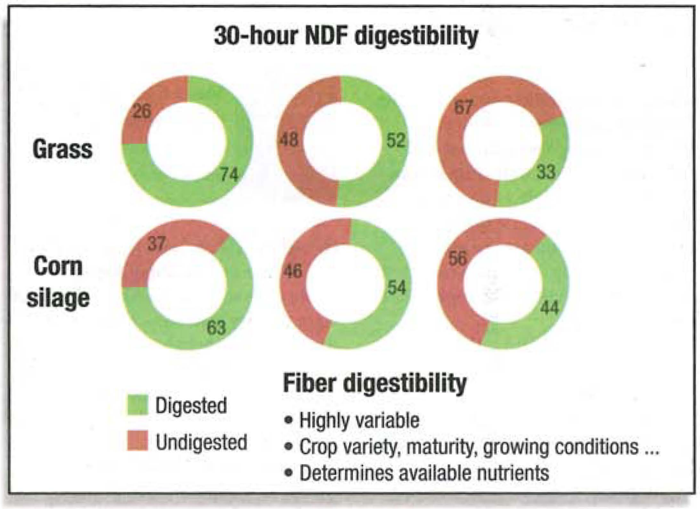
How much can you feed?

Starting point: 28% NDF in the ration

Allowable fNDF = 28% x 75% from forage = 21%

Allowable forage = allowable NDF% / forage NDF%

Figure 3 Neutral detergent fiber digestibility can vary greatly within forage type



Source: Hall and Mertens, 2012.

High-quality or right-quality forage, cont'd from page 77

- *Digestibility:* A forage with more slowly and less extensively fermentable fiber – think straw – will be more effective than the same amount and particle size of a rapidly and more extensively fermented fiber because it will stay in the rumen longer to encourage rumination.

- Additionally, the density, hydration and fragility of the particles can also have effect.

Although we do use shaker boxes to see what profile of particles we're offering to the cow, we still do not have a complete system to tell whether we're providing enough physically effective fiber. The cows are the only ones that can judge this. You need to walk out among the cows and check:

- *Cud chewing:* 50 percent of all animals not sleeping, eating, drinking or in heat should be chewing their cuds. In heat stress, the percentage may be 5 to 10 percent lower, but that may also mean you need to cool the cows.

- *Manure:* no diarrhea or very loose manure. The great majority of particles in rinsed manure should be no longer than a half-inch. Long particles in the manure mean that feed escaped the rumen too soon and was not properly digested (**Figure 1**, page 77). In a pen of animals all getting the same TMR, the manure should be 95 percent consistent. If not, see if the animals are sorting their feed. If animals are sorting, each animal may be getting a different ration, and their manure will be just as variable.

Composition

Composition is the basic information you get on your feed analyses that is the starting point for formulating rations. Dry matter percent, protein, NDF, energy, starch, water-soluble carbohydrate (includes sugars), fat, ash, minerals, etc. The 2001 Dairy NRC has recommendations for how much total or forage NDF and non-fiber carbohydrate (NFC; sugars, starch, pectins, etc.) could be fed to support production and health (**Table 1**, page 77).

You'll notice that as the percentage of forage NDF in the ration increases, so does the allowable amount of NFC. This gives credit to forage fiber for encouraging cud chewing and rumen buffering, which can counter the acid made by the microbes fermenting the NFC in the rumen and prevent ruminal acidosis. Alternatively, Dr. David Mertens had recommended that forage NDF should provide approximately 75 percent of total NDF in the ration or 0.9 to 1 percent of a cow's bodyweight.

We have long known that slowly digesting or indigestible parts of feeds can limit intake; there's only so much mass a cow can fit into her gut. Considering that NDF is the least digestible part of the ration, we can use forage NDF to make a rough estimate of the limits on how much of a given forage you can feed (**Figure 2**). Take the percentage of NDF you want in the entire ration and multiply it by 75 percent to give the percentage of forage NDF to include in the ration. Then divide the result by the percentage of NDF in the forage to give the amount of forage you could feed. Very low-fiber forages can be included at higher levels than high- fiber forages.

Warning: These calculations don't take fiber digestibility into account, and they don't promise how much the cows will produce. But it does give a sense of how fiber content affects how much of a forage you can feed. And whatever you do, don't feed spoiled or moldy feeds.

Digestibility

Forage digestibility affects protein and energy supply to the cow. We usually consider that most of the NFC (if the grain is properly processed and has the desired moisture content) and the protein are pretty digestible, so we focus on digestibility of the forage fiber. Neutral detergent fiber digestibility (NDFD), as measured by allowing rumen microbes to digest the fiber for 24, 30 or 48 hours, can give responses that vary widely by forage (**Figure 3**). Greater digestibility means more energy available to the cow. The more digestible the forage, the more the cow will be able to eat because there will be less indigestible material taking up space in her rumen. If the forage fiber is very digestible, that may reduce time in the rumen so the forage will be less physically effective than a less digestible fiber of the same particle size.

> "The herds monitoring particle size showed significantly higher milk production compared to the herds not monitoring particle size."

Fiber digestibility is a very useful tool for evaluating forages, but it's not a scalpel. In analyses of NDFD that were properly run in a single laboratory, repeated runs on a single forage sample gave values that fell in about a 10 percent range 95 percent of the time. That's about plus-or-minus 5 percentage units around a mean. If you send the forage sample to multiple labs that run it multiple times, the range is about 13 percent, or plus-or-minus 6.5 percentage units around the mean. This is with labs doing a good job of analysis. Forage NDFD is very useful for comparing forages and for adjusting energy values of forages, but it could not tell that forages were different unless they were more than 5 percentage units of NDFD apart.

Amount

Amount of forage is another aspect of quality. But only in the sense of that you need enough of the right-quality forages to feed your herd for the entire year.

What to do?

- Balance first with forages. They dictate the ration's base. Build around that.

- Aim to meet cow fiber and nutrient needs within the bounds of present recommendations.

- Work with the cows to figure out the details. **PD**

References omitted due to space but are available upon request.

Manure on Perennial Forages: Benefits & Challenges

Bill Jokela, U.S. Dairy Forage Research Center

Why apply manure on alfalfa and other perennial forage crops? There are several benefits, but also some concerns or challenges to be considered. For many farmers, the most important benefit of applying manure to perennial forage crops is it increases the acreage base, which may be important to meet nutrient management plan requirements and avoid over-application of phosphorus. Additionally, applying manure after harvest during the growing season opens up windows of time for manure application not available with most annual crops.

Alfalfa and other forages have a large nutrient need – potassium, phosphorus, sulfur, micronutrients, and for grass forages, nitrogen. Manure is a good nutrient source and can produce yield increases if nutrients are deficient.

While alfalfa and other legumes do not benefit from nitrogen in manure, applied nitrogen reduces the amount of symbiotic nitrogen fixation, helping to buffer nitrogen availability and reducing nitrate leaching risk due to nitrogen application from manure. Alfalfa's deep rooting pattern can capture nitrate leached beneath the root zone of other crops from excessive manure or fertilizer nitrogen application.

On the flip side, there are also some challenges or limitations associated with manure application on forages – smothering and leaf coating, soil compaction and crown damage from wheel traffic, pathogens and feed contamination, surface runoff of nutrients, and odor and ammonia emissions. Most of these concerns are associated with broadcast application after harvest and will be discussed in a second article in the August edition of Forage Focus.

When to Apply

There are three general manure application strategies or times of application: preplant (before forage seeding), following last harvest at termination of the stand, and after a harvest during the season.

Preplant application. Before planting is a good time to apply manure, especially on medium- to fine-textured soils deficient in phosphorus and/or potassium, so manure can be incorporated. Manure applied at this time must be thoroughly mixed with the soil to avoid seedling damage from manure-seed contact.

Research has shown yield benefits from preplant application. Liquid dairy manure was applied before seeding of alfalfa at three sites, two in Minnesota (Rosemount and Waseca) and one in Wisconsin (Marshfield) (Kelling and Schmitt, 2003). Seeding year yields were greater than or equal to those from the treatment with phosphorus and potassium fertilizer and the no-fertilizer control at two of the sites. At the Waseca location, manure did not increase yields because of severe compaction with the large equipment. During the first full production year, yields from manure were greater than both control and fertilizer treatments at all sites. The yield benefit from manure compared to that from phosphorus and potassium fertilizer was attributed to some combination of other nutrients (e.g., sulfur, boron), soil physical and/or microbial effects, and possibly nitrogen in the seeding year.

Application before stand termination. Application after the last harvest, just before termination of alfalfa or other perennial forage, is a favored time of manure application because it avoids any potential damage to the forage stand and provides nitrogen for the following crop (e.g., corn). However, nitrogen mineralization after alfalfa termination often meets or exceeds the need of the following crop, resulting in high levels of soil nitrogen and increased risk of nitrate leaching. The extent of this phenomenon depends on soil texture, the characteristics of the manure and how much is applied, as well as the density and quality of legume in the forage crop.

A summary of research results from 61 sites in Iowa, Wisconsin, Minnesota, and Pennsylvania determined that only seven sites showed any corn yield response to fertilizer nitrogen the first year following alfalfa plow-down (Kelling and Schmitt, 2003). A comprehensive review of recent research in Minnesota, as well as many other published results (Yost et al., 2015: 259 trials total), also concluded first-year corn after alfalfa is not likely to respond to fertilizer nitrogen application on medium textured soils. The response depends on specific factors such as length of alfalfa stand and early season soil conditions.

Thus, applying manure before terminating an alfalfa stand is not recommended because the resulting high levels of soil nitrogen are likely to exceed the need of the following crop and increase the risk of nitrate leaching. If it cannot be avoided, take care to limit the application rate to avoid excessive nitrogen.

Topdress after harvest during season. Surface broadcast is the dominant method of manure application for alfalfa and other perennial forages in North America. The wide spreading pattern of broadcast application reduces wheel traffic over the field and increases the speed of application. Broadcast slurry can also increase yields of forages, especially grasses. Much of the research on manure application on grass forages has been done in Europe, where most of the forage production is grasses. There has been some work done in North America.

Research in the Upper Midwest (MN, WI, IA) showed grass forage yield increases of 150% or more from broadcast manure compared to a no nitrogen control (Schmitt et. al, 1999). In research from Vermont (Carter et al., 2010) and British Columbia (Bittman et al., 2007), liquid dairy manure increased grass yields 90-100%, approximately equal to that from fertilizer nitrogen.

Application of liquid manure on established stands of alfalfa has had mixed research results, showing yields with topdressed slurry increasing, decreasing, or having no effect in Minnesota and Wisconsin (Kelling and Schmitt, 2003; Coblentz et al., 2014), Maryland (Min et al., 1999), and Italy (Ceotto and Spallacci, 2006). Probably the most comprehensive study was in Ontario in which liquid dairy manure was band-applied using drop-hoses with fan nozzles twice annually to 49 alfalfa cultivars at 4,500 gal/ac for three years (Bowley et al., 2009). Average alfalfa yields were increased 14% with manure compared to the no-manure control, with some cultivars showing much larger yield responses to manure than others.

Challenges with broadcast manure application, as well as alternatives to this application method, will be discussed in the August Forage Focus.

WISCONSIN PUBLIC RADIO

Why Kewaunee County Is a Flashpoint for CAFOs and Water Quality

Geology, Manure Irrigation Combine with Powerful Consequences in Northeast Wisconsin

Thursday, June 30, 2016, 1:35pm
By Scott Gordon

Kewaunee County, home to about 20,000 people on the lower half of the Door Peninsula, is hardly the only place in Wisconsin that's seen a rapid growth of concentrated animal feeding operations, or CAFOs. Nor is it the only area in the state where there are problems with bacteria and nitrate contamination in its drinking water. The county has, however, become central to a debate over how to regulate manure irrigation, an increasingly used process in which farms spray liquefied animal waste to fertilize fields.

A state-commissioned report issued in April didn't yield consensus on the issue among a working group of academics, state regulators, county-level health officials, farmers and Ag industry representatives. In late June, the Wisconsin Department of Natural Resources-facilitated Groundwater Collaboration Workgroup — focusing on Brown, Door and Kewaunee counties and comprised of local residents, state and county officials and farmers — issued another report making several recommendations for aiding residents with contaminated drinking water and minimizing the impacts of manure irrigation. In the wake of that report, Kewaunee County residents are continuing to call upon the DNR and U.S. Environmental Protection Agency to open the door for emergency water supplies for people whose wells have been compromised, and for large dairy operators to do more to reduce pollution. People working on these issues in northeastern Wisconsin hope to provide guidance that can be used to help communities across the state navigate them.

It makes sense that Kewaunee County residents might feel especially vulnerable to bacterial pollution of its drinking water.

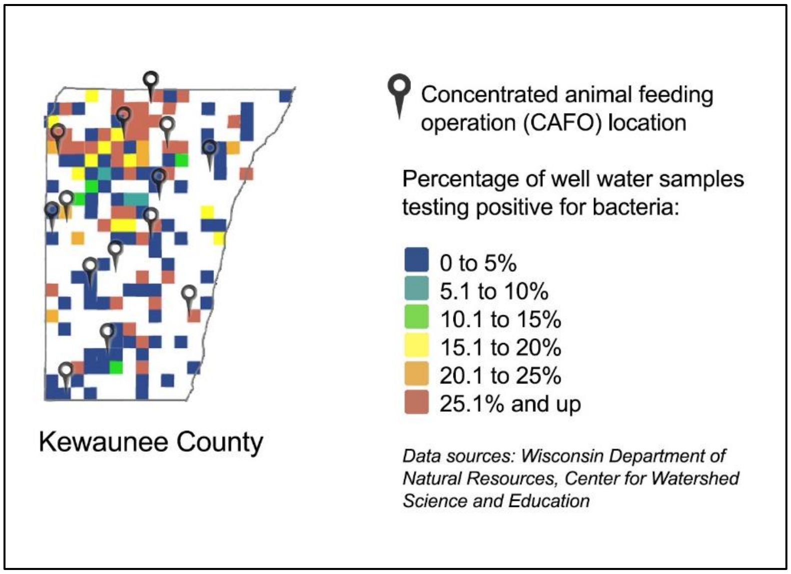
DNR records show the county has 16 CAFOs operating within its 343 square miles — a high count even compared to other rural, agriculture-intensive counties around the state. Despite being along the shores of Lake Michigan, Kewaunee County households and businesses depend almost entirely upon groundwater sources for their drinking water needs. Less than half of its residents get their water from public utilities, which can carry out treatment processes like disinfection to address bacterial contamination. Rather, most people draw their drinking water from private wells. These sources are largely unregulated, and property owners must monitor for and treat any contaminants on their own. Finally, a lot of this groundwater is under relatively thin soil and bedrock with lots of cracks in it, a type of geologic formation known as karst. This foundation can make it easier for bacterial contaminants to seep in not only from farms, but from leaking septic systems as well.

"Mostly just the karst features allow direct infiltrations of things from the surface to reach groundwater there," Rebecca Larson said, a University of Wisconsin-Madison professor of biological systems engineering and UW-Extension specialist. Larson pointed out that this issue is not limited to CAFOs — large farms cannot spread manure in areas where the depth to groundwater is less than two feet (still relatively shallow), but smaller farms have no such restrictions.

"We have definitely outlined that there are areas where the sensitive features are, and some of those lands are still receiving manure," she said.

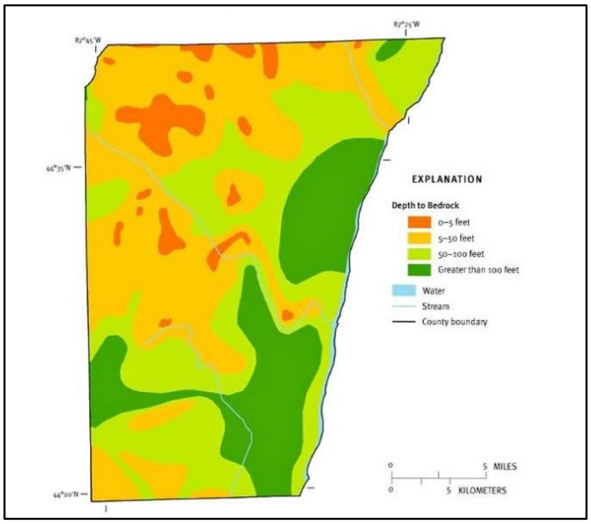
Monitoring data collected by state agencies provides some geographic perspective on water contamination in Kewaunee County, especially those related to mounting concerns over bacteria and viruses. The Wisconsin Well Water Quality Viewer, developed by the Center for Watershed Science and Education at the University of Wisconsin-Stevens Point, provides geographic data on bacterial contamination findings, based on tests sampling for E. coli and other coliform bacteria. This information presents results by small geographic units, called "sections." Most of the data is based on just a small number of samples — if, say, two of four samples in a given geographic area tested positive for E. coli, that would land it in the most contaminated category.

The following map shows the location and intensity of groundwater bacteria tests across Kewaunee County. Some clusters highlight where bacteria seems to be especially prominent in groundwater, particularly in northern and western parts of the county. Many of the high-indicator areas are also located near CAFOs, though these facilities are spread throughout the county.



A map of Kewaunee County indicates the location of bacterial contamination in well water test samples and the sites of concentrated animal feeding operations. *Scott Gordon/WisContext*

Another important factor are those layers of soil and the cracked geology beneath them. A map in the Groundwater Collaboration Workgroup report, drawn from a 1987 DNR survey, shows that Kewaunee County's bedrock is shallower in wide swaths of its northern, western and southwestern portions. These areas are also where well testing data shows the higher instances of bacteria.



Portions of Kewaunee County have relatively shallow soil, which makes groundwater more susceptible to contamination from above. *Wisconsin Department of Natural Resources*

How much bacterial contamination comes from animal waste and how much comes from human waste is an open question, said U.S. Department of Agriculture microbiologist Mark Borchardt, who has conducted extensive research on groundwater contamination in Wisconsin. He is currently leading a DNR sanctioned study that aims to fill gaps in what scientists and regulators know about water pollution and its sources in Kewaunee County. This study's testing will be more extensive and randomized than previous rounds of sampling in the area and will focus on distinguishing between human and animal fecal contamination.

It's clear that northeastern Wisconsin has high levels of groundwater contamination, Borchardt said, but he doesn't think there's enough information available right now to draw strong conclusions.

"I would be reluctant to point my finger at the dairy industry and reluctant to point my finger at the septic systems," he said.

For one, the pathogens identified so far in Kewaunee County groundwater are types found in both human and animal feces, making it difficult to pinpoint contamination sources or determine how these bacteria and viruses are traveling. Despite his concerns, Borchardt is optimistic that the discussion in northeastern Wisconsin will help the state develop better overall approaches to protect its groundwater, in part because the area provides such a complex challenge.

"Wherever you have this fractured dolomite (a type of mineral making up much of the bedrock in eastern Wisconsin) and shallow soils, it's an issue," he said. "And there's more cows and there’s more people, and there's more poop."

Larson hopes the current research and debate leads to some immediate changes in northeastern Wisconsin, like getting more farms to adopt nutrient-management plans and treat their manure for pathogens. And what works there won't always work in every part of the state.

"The site-specific condition will dictate what kind of rules should be implemented," Larson said. "Although in this area we have some sensitive features, in areas where that's not the case, we need to be careful that we may be adding regulations that are unnecessary, and they may need regulation in different ways."

Whatever the local conditions, Larson sees at least one lesson emerging that all farming communities across Wisconsin can take to heart: Plan ahead, before there's a water-quality crisis.

Editor's note: Why Kewaunee County Is A Flashpoint For CAFOs And Water Quality was originally published on WisContext, which produced the article in a partnership between Wisconsin Public Radio, Wisconsin Public Television and Cooperative Extension.

Manure on Perennial Forages: Benefits & Challenges, Part 2

Bill Jokela, U.S. Dairy Forage Research Center

While manure topdress applications may increase perennial forage yields and provide other benefits (Part 1, May 2016 *Forage Focus*), there are a number of challenges associated with broadcasting manure after harvest.

1. Excessive manure rates can cause smothering and coating of plants, resulting in leaf scorching and clogging of pores.
2. Wheel traffic from loaded spreaders can damage crowns and compact soil, especially under wet soil conditions. This can sometimes result in stand loss and yield decline.
3. Manure often contains pathogens, so there is a risk of feed contamination and aerial or runoff transport.
4. Odor may be a nuisance issue affecting neighbors.
5. Ammonia emission can represent a significant grass forage economic loss and is a growing environmental concern.
6. Nutrient runoff can lead to lake and stream eutrophication, especially with late-fall and winter applications.

The impact of these concerns can be minimized by careful management (e.g., spreading soon after harvest, avoiding wet soil traffic, avoiding excessive rates). Use of alternative application methods can offer another approach to limit negative effects.

Alternatives to Broadcast Application

Concerns about broadcast manure have led to the development of alternative application methods including shallow injection, surface banding above canopy, banding on soil surface with drag-shoe or trailing-foot, and tine aeration band application. These methods can reduce potential damage since manure is applied in narrow bands directly in soil or on soil surface, often underneath crop canopy, thereby limiting direct contact of foliage with manure.

Aerator/banded manure – aerator slots

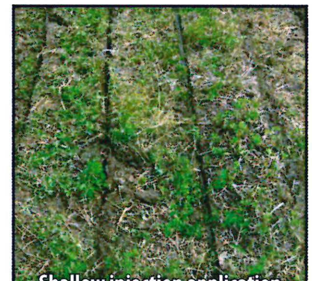
What does the research say? Grass forage yields in British Columbia increased 7% by banding dairy slurry with a drag-shoe compared to broadcast application, but yields increased more by banding manure with tine aeration (Bittman et al., 2005). Banded manure/tine aeration also reduced ammonia emission ~50% and runoff nitrogen and phosphorus loss 50-90% (Bittman et al., 2005; van Vliet, 2006). Band application of liquid dairy manure in Vermont reduced ammonia emission 27-46% (depending on rate) and increased yields in two of four site-years compared to broadcast application (Pfluke et al., 2011; Carter et al., 2010).

There has been less research with alternative application methods on alfalfa. Ontario research (Bowley et al., 2009, discussed in the first article) showed a 14% yield increase from surface-banded dairy slurry compared to a no-manure control, but only a 10% yield increase from banded manure following tine-aeration. Authors suggested this may have been the result of increased manure-root contact by infiltration of manure into the aerator slots. In a Saskatchewan study (PAMI, 2001), injection of manure increased alfalfa yields on a low fertility site, but decreased yields on a high fertility site due to stand damage, suggesting yield effect depended on the balance between yield response to manure nutrients and mechanical damage from injection.

Ongoing Wisconsin Research

The U.S. Dairy Forage Research Center has completed two years of a three-year study evaluating different methods for applying liquid dairy manure on alfalfa. The following treatments were applied to established alfalfa on Withee silt loam (somewhat poorly drained, 1-3% slope): control (no manure, fertilizer based on need), broadcast liquid dairy manure, surface banded manure; aerator/banded manure (AerWay SSD), and shallow injection (Yetter Avenger).

Manure was applied annually after first (2015) or second (2014) harvest with an 1,800 gallon research model spreader (Nuhn Industries), with a target application rate of 4,000-5,000 gal/ac. Equipment adjustment problems in 2014 resulted in an excessive rate (~10,000 gal/ac). There were no significant treatment effects on yields in the first harvest after the August 2014 manure application, nor on the next harvest in June 2015, suggesting there was little or no stand damage due to manure or mechanical effects of application equipment (despite high application rate); neither was there a yield benefit from manure nutrients. However, yield from shallow injection was slightly lower than most other treatments in the first harvest (July 22) following the 2015 manure application. But the yield effect had disappeared by the next harvest in August.


Shallow injection application

Preliminary results from the first two study years show minimal effects of manure application on yield compared to the no-manure control (optimum or higher soil test phosphorus and potassium); however, there was some indication of a short-term (one harvest) decrease in yield from the injection treatment. Injection greatly decreased ammonia emission, but there may be a trade-off with increased greenhouse gas (nitrous oxide) emission.

Conclusion

Potential benefits of applying manure on perennial forages include increasing acreage for manure application and timing flexibility. Yield may be increased, especially for grass forages and on sites needing nutrients. However, yields may be unaffected or even decreased in some cases. Potential advantages need to be considered in the context of some concerns – manure or wheel traffic plant damage, nutrient runoff, excessive nitrogen at stand termination, and others.

Most of these risks can be minimized by careful management (e.g., spread soon after harvest, avoid excessive rates and traffic on wet soils, avoid application at stand termination if the nitrogen credit is adequate for the next crop). Several innovative liquid manure application methods offer additional options to improve nitrogen utilization, minimize forage contamination, decrease nutrient runoff, and provide more uniform application. Success of manure application on alfalfa depends on the specific conditions at the site and good decision-making by the manager.

Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture.

Study identifies public health risk from irrigating dairy manure

***Progressive Dairyman* Editor Karen Lee**

This article originally appeared in the PD Extra enewsletter. Sign up at www.progressivedairy.com/enews to receive new online articles before you see them in print.

> “The most important variables for airborne concentrations of microorganisms during manure irrigation are the distance, wind speed and initial pathogen concentrations in the manure. These were the three most important variables.”
> — Dr. Mark Borchardt

A first-of-its-kind field study was recently completed to estimate the risk of acute gastrointestinal illness from airborne pathogens during manure irrigation and to identify the other variables, such as distance and weather conditions that affect airborne pathogen transport. It coincided with a larger effort, known as the Manure Irrigation Workgroup, to explore benefits, concerns and remaining questions associated with manure irrigation.

In an April webinar explaining the findings of the work group, Dr. Mark Borchardt, research microbiologist, USDA Agricultural Research Service, shared how the study was conducted and its results.

During irrigation, manure takes on two different forms – droplets and aerosols. The droplets are heavy and fall to the ground, while the aerosols become airborne. In the air, they become dispersed and diluted. Some will undergo inactivation due to solar irradiance, high temperatures and low relative humidity. The remaining microbes have the potential to reach people through inhalation, landing on their skin, on food they may consume or a vector object, such as a pet. For this study, the researchers focused on direct inhalation.

The large, multidisciplinary study used three approach methods – field data, modeling and risk assessment.

Field data

Borchardt said measurements were collected from 25 field trials on active dairy farms that used a traveling gun, center pivot or tanker with a splash plate to irrigate manure. Due to certain circumstances, only 21 trials were entered into the data set.

Each trial had a portable weather station that continuously collected data. The irrigation events took place during a wide range of weather conditions, with temperatures logged from 42°F to 88°F, relative humidity from 28 percent to more than 80 percent, wind speeds from 2 mph to 13 mph, wind gusts from 4 mph to 21 mph and solar irradiance from darkness to a bright blue Wisconsin June day, he said.

Microbe concentrations were measured at multiple distances from the point of manure application. They were measured with qPCR to get a genetic signal and culture methods to see visible bacteria.

One particular set of culture samples that Borchardt shared was taken on May 22, 2014, from a traveling gun manure irrigation event. Wind speed was 11 mph, temperature at 68°F, 50 percent relative humidity and solar irradiance at 530 watts per square meter. When the samples were placed on culture plates, gram-negative bacteria was absent for the sample collected upwind. There were high concentrations at the point of application, but only two colonies appeared at sample distances of 100 and 350 feet away from the application site. By 500 and 670 feet, no colonies appeared on the culture plates.

“Remember, we have deposition, dispersion (dilution) and inactivation, so we’re left with lower concentrations,” Borchardt said. “Nonetheless, this doesn’t tell us anything about health risk.”

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Modeling

Statistical modeling was then used to predict air concentrations for risk assessment and relate air concentrations to weather conditions and microbe concentrations in manure.

"The most important variables for airborne concentrations of microorganisms during manure irrigation are the distance, wind speed and initial pathogen concentrations in the manure. These were the three most important variables," Borchardt said.

He continued, "Surprising to us, sunshine didn't turn out to be that important and relative humidity wasn't all that important either."

Risk assessment

There are two ways to assess the health risk for infectious disease. The first is to look at groups of people, which wasn't a viable option here. The other is to use quantitative microbial risk assessment, which relies on dose-response models to estimate the dose of the pathogens and the probability of illness.

Using the quantitative assessment, Borchardt said inputs included pathogen prevalence, distance, age, inhalation rate and time spent outdoors.

He reported it was rare to find pathogens in the manure samples from the three farms in the field study. If a pathogen was present, it was campylobacter. They did not find any salmonella or E. coli.

Therefore, two pathogen surrogates were used to conduct the assessment. These microbes are friendly and typically found in the gastrointestinal tract of the cow. Bovine bacteroides is relatively resistant to inactivation in the environment and provided a worst-case scenario. Gram-negative bacteria was the other surrogate. The ratios established for each were related to the amount of pathogens found in stored manure as cited in established literature.

They looked at four different scenarios reflecting a different level of conservatism to protecting public health. The least conservative view was using the typical prevalence of the level of pathogens with the gram-negative strain. The next was a little more conservative with a typical prevalence, but with the more environmentally resistant bovine bacteroides strain. Then they looked at 100 percent prevalence (saying all dairies have the pathogen) for each type of pathogen surrogate.

In the U.S., there are two acceptable levels of risk for acute gastrointestinal illness. The first is set for drinking water at 1 in 10,000 people per year. The second is for recreational water exposures (e.g., beaches), which is at 32 out of 1,000 swimmers per event. "We used those two because it's the only benchmark we have available to us," Borchardt said.

Looking at the median of the risk of distribution – the point at which 50 percent of the risk estimates are above and 50 percent below, which is typical in a quantitative microbial risk assessment – all four scenarios were somewhere between the acceptable risk levels for drinking water and the acceptable risk levels for recreational water in the U.S.

They also studied the 75th percentile of the risk distribution where the risk levels are higher. For the most part, the scenarios were within the acceptable range, with the exception of the most conservative scenario – figuring all dairies have environmentally resistant bacteria – where the risk estimate for salmonella falls below acceptable drinking water levels when at a distance of 500 feet or less from the irrigated manure.

Various risk estimates were done, because it will be up to policy makers to determine how conservative the policies need to be towards protecting public health, whether it is the median level of risk, the 75th percentile or any other level of risk.

By using actual field data, state-of-the-art statistical modeling and risk assessment methods, this unique study was utilized by the Manure Irrigation Workgroup as it made its recommendations for the irrigation of manure from dairy farms.

In short, Borchardt found that illness risk is on the order of 1 in 100,000 to 1 in 100 per irrigation event at 500 feet downwind from the application. That risk level is dependent upon pathogen type and pathogen prevalence. Risk can also be impacted by downwind distance and the number of irrigation events. **PD**

The second experiment had heifers that were overcrowded at the feedbunk (133 percent). Their control diet was similar to the first study, but the diluting feeds included chopped straw and chopped corn fodder, as well as eastern gamagrass haylage. Photos courtesy Wayne Coblentz.

Is overstocking affecting your heifer management?

Kelli Boylen for *Progressive Dairyman*

How much impact does heifer stocking density have on their conditioning?

Many herd managers seek to prevent freshening heifers from being overconditioned by dietary dilution with low-energy forages. Another common management technique to prevent overconditioning is precision or limiting feeding.

"Both strategies have advantages and disadvantages, and the effectiveness of both management approaches can be affected by overcrowding," says Wayne Coblentz of the USDA-ARS, U.S. Dairy Forage Research Center located in Marshfield, Wisconsin.

Recent research conducted at the Marshfield Agricultural Research Station addressed management questions associated with the dietary dilution strategy.

The first experiment involved using eastern gamagrass (a perennial warm-season grass with neutral detergent fiber concentrations of 75 to 80 percent in mid-August). It was substituted for corn silage within alfalfa haylage/corn silage diets when trial heifers were stocked in pens at 100 percent of capacity. This strategy limited weight gains by reducing the energy density of the diet and by restricting voluntary intake. Daily weight gains were reduced linearly with the serial addition of gamagrass haylage, and there were none of the sorting behaviors often associated with straw, Coblentz says.

Within this trial, it was necessary to replace about half of the corn silage with eastern gamagrass haylage to reduce weight gains to a commonly recommended range (1.8 to 1.9 pounds per day), Coblentz says. "Eastern gamagrass is a distant relative of corn and native forage that grows in most areas of the U.S. Growing eastern gamagrass probably isn't for everyone, but the work illustrates a couple of points: There are non-sortable alternatives to straw, and weight gains are limited by reducing both the energy density of the diet as well as voluntary intake."

The second experiment had heifers that were overcrowded at the feedbunk (133 percent). Their control diet was similar to the first study, but the diluting feeds included chopped straw and chopped corn fodder, as well as eastern gamagrass haylage. The heifers were not overcrowded in regard to available freestalls.

All diluting feeds used in the second study were effective in reducing nutrient intakes as well as daily weight gains. However, heifers receiving chopped straw had daily weight gains the closest to ideal. Coblentz says the heifers did sort the diets that included wheat straw and corn fodder, but the sortability of the diets could not be related directly to daily weight gains.

Coblentz says that within this trial, corn fodder was extremely sortable, while eastern gamagrass haylage was mostly unsortable, yet weight gains for heifers consuming these diets were similar but greater than gains for heifers consuming diets with chopped straw.

"Diets were offered daily for a minimal amount of refusal (less than 2.5 percent), which is consistent with University of Wisconsin recommendations for including chopped straw in TMR diets. With the limited rate of crowding at the feedbunk, coupled with this type of feeding management, heifers still sorted diets diluted with low-energy forages. Although there were numerical trends for more variability with respect to individual weight gains within each pen as diets became more sortable, these trends were not statistically significant."

He continues, "Generally, we found a greater percentage of heifers eating diluted diets three and seven hours post-feeding than the alfalfa haylage/corn silage control diet. Conversely, a greater percentage of heifers assigned to the control diet were lying in stalls at those time intervals post-feeding."

Coblentz says this second experiment suggests that offering diets with diluting agents, such as straw, for minimal daily refusals encourages near complete consumption of the TMR within a 24-hour period and may reduce the effects of diet sortability on animal performance.

He says, "This approach requires closer management but forces consumption of the diluting agent within a 24-hour period. Overfeeding (high refusals) may allow less desirable dietary components to build up in the bunk, potentially causing more problems with variable weight gains."

A third experiment, still ongoing, had heifers stocked at the feedbunk and freestalls at 100, 125 and 150 percent of capacity. Thus far, it seems that overstocking affected the mean weight gains minimally, but some evidence of greater variability within the pen was observed as stocking rate increased. In theory, this probably occurs because dominant heifers monopolize the feedbunk and sort the more desirable components of the diet, leaving passive heifers a poorer-quality diet to consume.

Overstocking freestalls and bunk space resulted in a greater percentage of heifers resting in the alleys or inactively standing during night hours instead of resting in freestalls. Although all heifers in the trial exhibited acceptable hygiene, overstocked heifers had somewhat poorer hygiene scores and more variability among scores within pens.

"Part of the reason for conducting this work is to determine answers to management questions, such as when is hygiene too poor, and when is stocking density too dense," he says.

The reality may be that the upper threshold for stocking varies from situation to situation. Hopefully, as a result of these studies, we can establish some clear guidelines for stocking rate, and good rules of thumb that may signal problems before they have severe consequences. **PD**

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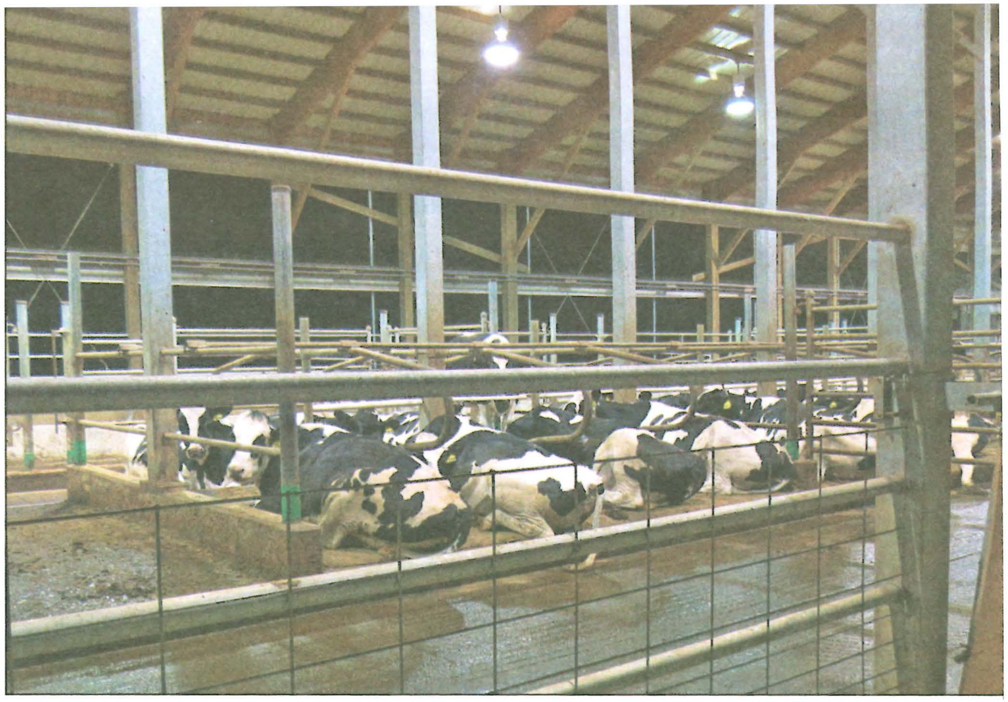

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