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Fecal coliform and *E. coli*: another environmental concern for dairies

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Discussions of environmental concerns related to dairy operations typically focus on nitrogen, phosphorus, or air quality. However, several other environmental issues are gaining attention in various areas of the country. One that has already become an important issue for dairy operations is bacteria in surface water.

Why are bacteria a concern?

Bacteria in surface water are a concern because of the risks to human health when infectious bacteria are present in the environment. The strain of *E. coli* bacteria most commonly linked to human health concerns is *E. coli O157:H7*. Although this strain is commonly associated with food borne illnesses, it is also a waterborne pathogen.

In 1995, the Center for Disease Control reported 12 cases of gastrointestinal illness associated with *E. coli O157:H7* in the water at a swimming beach. In New York in 1999, a contaminated well was the source of *E. coli O157:H7* that resulted in culture positive stool samples from 116 people that drank the water while attending a fair.

Why is surface water criteria usually based on coliform, fecal coliform, or generic *E. coli* bacteria if *E. coli O157:H7* is the bacteria implicated in human health concerns? The more generic classes of bacteria are used because they indicate the presence of fecal contamination and raise concerns that one of the infectious strains of bacteria may be present. At this time, the Environmental Protection Agency has chosen to use indicator bacteria to determine when fecal contamination in surface waters needs to be addressed.

Historically, the indicator bacteria for fecal contamination has been fecal coliform bacteria. When fecal coliform bacteria were used for monitoring, the national standard was set at 200 colony forming units (CFU) per 100 milliliter for recreational water. Recently, EPA determined that *E. coli*, instead of fecal coliform, would be used as the standard indicator bacteria for the coliform group. At this time, the national *E. coli* standard for recreational waters is 126 CFU/100 ml. When the concentration in surface water exceeds these standards, steps must be taken to reduce bacterial loading to these waters.

When fecal bacteria counts in water samples exceed the state, territory, or tribal standards for water quality, a water body is considered to be impaired and a Total Maximum Daily Load (TMDL) may be initiated.

The development and implementation of a TMDL begins with the listing of a water body under section 303(d) of the 1972 Clean Water Act. A water body may be listed under section 303(d) when a pollutant of concern, such as nutrients, sediments, chemicals, or pathogens, exceeds the standards set by the state, territory, or tribe. Once a water body is listed as being impaired, a TMDL must be developed to decrease the amount of the given pollutant causing impairment.

A TMDL will address the maximum loads of the pollutant from both point (i.e. factories, wastewater treatment plants) and nonpoint sources (i.e. farmland, forested areas) that can be received by a water body and still meet the standard (EPA, 2006). The implementation stage of a TMDL addresses strategies to decrease the contributions of the pollutant to the water body.

Depending on the development and implementation process, a TMDL can have major implications to dairy operations.

E. coli on dairy operations

Cattle have been implicated as a major reservoir of generic *E. coli*, and, more specifically, of *E. coli O157:H7* (NAHMS, 2002). Recently, certain *E. coli* strains, such as *E. coli O157:H7*, have been identified as environmental pollutants and human health concerns. However, *E. coli O157:H7* has only rarely been associated with disease in cattle, which does not mean that *E. coli* bacteria are not a problem for the typical dairy operation.

Complications from other strains of *E. coli* bacteria are commonplace occurrences on farms across the United States. For example, *E. coli* is a pathogen that complicates the raising of neonatal calves. Clinical signs of *E. coli* infections in calves include diarrhea induced dehydration and endotoxic shock. In mature lactating dairy cattle, *E. coli* bacteria are a well-recognized cause of clinical mastitis.

In 2002, the USDA's National Animal

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Health Monitoring System (NAHMS) conducted the "Dairy 2002" study, the third national study of U.S. Dairy Operations carried out by this organization. Results of Dairy 2002 indicated that 38.5 percent of dairy operations sampled had one or more *E. coli O157* culture-positive cows. Large operations (500 or more cows) were more likely to have *E. coli O157* culture-positive cows (53.9% of operations) than medium (100 to 499 cows) and small (less than 100 cows) operations (36.1% and 29.4% of operations, respectively).

E. coli O157 has been found in raw milk samples, although this strain of bacteria has not been specifically implicated as a cause of clinical mastitis in lactating dairy cattle. The presence of *E. coli O157:H7* in raw milk, which is thought to be a result of fecal contamination, can cause gastrointestinal infections in children consuming the raw milk.

All strains of *E. coli* (including *E. coli O157:H7*) are readily killed by pasteurization at 145ºF, thus *E. coli* is not a concern in pasteurized milk products.

Survival and movement of *E. coli* in the environment

E. coli are very well adapted for survival in natural environments and are widely distributed in soil and bodies of water throughout the world, particularly in tropical environments. Once *E. coli* are present in the environment, the bacteria easily survive if they have a source of carbohydrates, such as a sugar or starch, and a source of nitrogen; which are both readily available in fecal material. *E. coli* are also extremely successful at altering their normal cell activity to adapt to stressful conditions when food sources are scarce.

Although *E. coli* bacteria can survive in the environment under certain conditions, there are several factors that naturally decrease *E. coli* numbers:

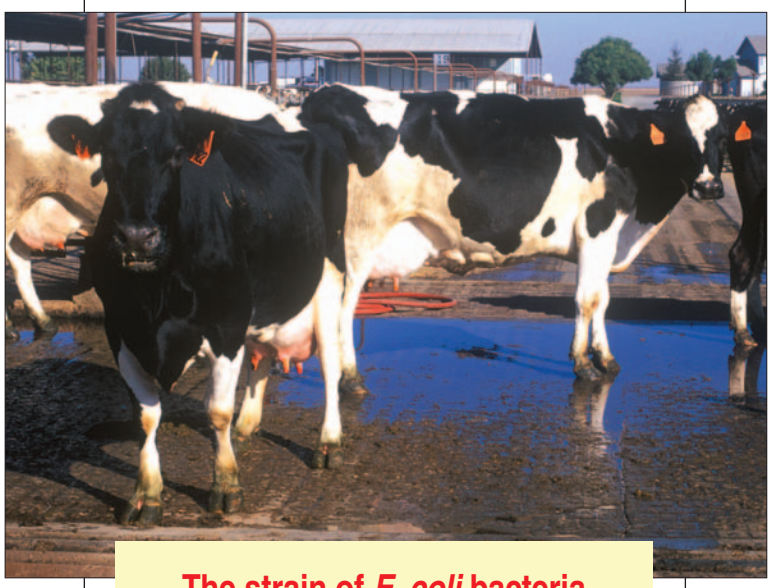
First, *E. coli* are sensitive to ultraviolet light, and excessive exposure decreases the survivability of the bacteria. Exposure to high amounts of sunlight in shallow bodies of water or streams often leads to decreased bacteria quantities. Unfortunately, *E. coli* can protect itself from the adverse effects of sunlight by sheltering in shade provided by floating mats of algae, in sand, or even amongst sea grasses and on tropical coral reefs when at sea. *E. coli* , when affixed to a protective site, are also resistant to the lethal effects of common water treatments, such as chlorine.

Another known natural deterrent to *E. coli* survivability is subjecting the bacteria to increasing quantities of oxygen. Thus, *E. coli* numbers generally decline in moving water, while stagnant bodies of water tend to be a more suitable environment to promote *E. coli* survival.

Research on *E. coli* persistence in soils is highly varied. Most studies are in agreement that *E. coli* persists longer in clay soils, with freezing temperatures, and when certain cover crops are present due to the interactions of *E. coli* with the plant root systems.

Other factors, such as the amount of manure applied to a crop greatly influences the duration of *E. coli* survival. High rates of manure applications (25 to 30 tons per acre) result in greater bacteria persistence, with survivability rates that may extend beyond a year. With more reasonable rates of manure application, the persistence of *E. coli* may be as short as a few days to a few weeks.

One of the reasons for reduced *E. coli*



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numbers in soil may be due to competition with other soil microflora. Research studies indicate that competition between microflora in the soil can cause rapid reductions in *E. coli* populations when bacteria from fecal material are introduced to the environment (Cote and Quessy, 2005).

Even though *E. coli* bacteria may be present in soils, there will not be a water quality problem if bacteria do not move to surface waters. Buffers are one of the best defenses for dairy producers to keep *E. coli* out of surface waters. A study by Atwill et al., 2006 found that even a small buffer of only 3.6 ft reduced the movement of fecal bacteria. Therefore, fencing off streams and waterways, as well as following recommended buffer distances for a given slope and soil type, greatly reduces the chances that *E. coli* will enter surface waters.

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Bacterial source tracking

Scientists are now able to determine if the source of *E. coli* bacteria within a watershed comes from human, livestock, or wildlife origin. Bacterial Source Tracking, or BST, is the methodology used to determine the source of bacteria.

There are two main categories of BST methods, phenotypic and genotypic. Phenotypic methods are based on characteristics expressed by fecal bacteria, such as antibiotic resistance, and genotypic methods are based on DNA sequences. Most BST methods require a host origin database to identify the source of environmental samples. Once a database has been developed, individual *E. coli* samples are matched to those in the database to determine the source of the bacteria.

Bacterial source tracking has the potential to greatly affect the implementation of TMDLs. One of the current difficulties with the TMDL process is uncertainty in identifying specific sources of fecal bacteria in water bodies. The BST methodology has been described as having the ability to turn nonpoint sources into point sources to the degree that it is possible to more accurately assign load allocations to specific sources and develop a scientifically-defensible TMDL. Use of BST technology could assure dairies under scrutiny that they are, or are not, the source of *E. coli* bacteria causing bodies of water to exceed water quality standards.

With the numerous potential sources of *E. coli* that can contribute to "hot spots," including urban run-off or natural sources of *E. coli* such as wildlife or forested land, BST can help to ensure dairies are not blamed for more than their share of the problem.

Summary

Fecal coliform and *E. coli* bacteria are being monitored in surface waters at local, state, and national levels. As concerns about the presence of *E. coli* are increased, potential sources of *E. coli* , such as dairy operations, are going to be blamed as being part of the problem. Although methods such as BST can assist in determining if dairy cattle are a source of bacteria, BST can be very expensive and may not be done in all of the water bodies trying to decrease levels of fecal bacteria.

In addition, BST studies often do not differentiate between various cattle sources and do not account for differences in management styles and environmental regulations across cattle operations.

Since dairy operations are often examined when environmental issues are raised, the industry already has, and can expect to be considered part of the problem when it comes to *E. coli* in surface waters.