Cows, Streams, and E. Coli: What everyone needs to know

Lois Wolfson, Institute of Water Research (wolfson1@msu.edu)
Tim Harrigan, Associate Professor, Biosystems and Agricultural Engineering (harriga1@msu.edu)

Introduction

Contamination of water by bacteria is one of the leading causes of impairment in U.S. surface waters. While many bacteria occur naturally in the environment and are an important component of many ecosystem processes, some are of concern because they may cause diseases. These bacteria (*E.coli* 0157:H7, Salmonella, etc.), as well as viruses (enteroviruses, adenoviruses, etc.) and some protozoans (Cryptosporidium, Giardia, etc.), are referred to as pathogens. Most are found in the gastrointestinal tract of humans and other warm-blooded animals and are shed in the feces.

One type of bacteria found in the intestines and feces is *Escherichia coli*. Most people refer to it as *E. coli*. It is an important type of fecal coliform bacteria that can help prevent the growth of harmful bacteria within the intestines. Although there are some strains of *E. coli* that cause illness, such as *E. coli* 0157:H7 (the strain often associated with food poisoning), most *E. coli* are harmless. The presence of *E. coli* can be used as an indicator of the presence of fecal contamination.

Water quality standards are set within States to limit exposure to recreational waters when pathogens are present. In most states, including Michigan, the organism (indicator) used to determine if the water quality standard for recreation is exceeded is *E. coli*, even though it is usually other bacteria, viruses and protozoa that cause many of the illnesses associated with swimming in and ingesting polluted water. If *E. coli* is present in certain quantities, then there is a greater probability that pathogens will be present as well.

Why don't we monitor directly for pathogens? Pathogens are very diverse, frequently mutate, and can be much more difficult and costly to measure. Also, large volumes of water are usually required for any test that may be done in a laboratory. Measuring just one pathogen does not provide information on the others that may also be present. Thus, presence of *E. coli* bacteria is used as an indication of the presence of pathogens. The EPA recommended standards for *E. coli* in recreational waters are based on a threshold concentration. When those numbers are exceeded, the health risk from waterborne illness is deemed unacceptably high[1].

Where Do These Bacteria Come From and How Do They Get Into Surface Waters?

Significant sources of fecal material to lakes and streams include wastewater discharge, stormwater runoff, and manure runoff. The fecal material in these sources comes from warm-blooded animals including humans, pets, wildlife, and farm animals. Many of the bacteria within feces can survive in environments outside of the animal, thereby elevating bacteria concentrations as they enter a stream. EPA estimates that one dairy cow can produce about 120 pounds of wet manure in a day, with 80 percent being water[2]. On the other hand, humans account for 3 to 6 pounds per day, and a goose averages about 0.34 pounds of wet droppings per day. These values indicate that even a small quantity of fecal material escaping into surface water from livestock can cause a substantial impact. Regardless of whether the polluting animals are sick or healthy, they can transmit pathogens in their manure. However, those that are sick are much more likely to shed pathogens. Thus, good on-farm sanitation practices, healthy diets and good animal husbandry will help decrease pathogen release from livestock[3].

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Fecal material also contains nutrients and organic matter. Nutrient addition to surface waters, particularly phosphorus and nitrogen, can increase algal growth, decrease water clarity, and increase ammonia concentrations which can be toxic to fish. The increased organic matter also serves as a food source for bacteria and other microorganisms, resulting in lower oxygen levels in the water, and often no oxygen in deeper bottom waters.

During a heavy storm, the precipitation can wash off the land and flow by gravity to lower areas; soak into the soil and either be taken up by rooted vegetation and/or continue flowing deeper (infiltrating) into the ground, eventually reaching groundwater; and/or evaporate back into the atmosphere. Soils have the ability to remove bacteria and other microorganisms by trapping them in pore spaces between the soil particles. However, studies have found that subsurface tile drains can be a contributor of bacteria to streams, particularly when cracks, worm holes, and other conduits in the soil provide a direct route from the surface to the tile drain[4].

Manure recently applied to land prior to a heavy rainfall or to wet ground, can also be washed into nearby streams. Additionally, livestock with access to streams are not only a direct source of manure to the stream but can also erode and damage stream banks as they enter the water, which also results in increased inputs of nutrients and sediment.

What are the Impacts to Water Bodies and Human Health?

As *E. coli* concentrations increase in surface waters, it is likely that some type of fecal contamination has occurred. When the concentrations exceed water quality standards, people are at a greater risk of coming in contact with pathogens. The most common illness associated with exposure (swimming, injestion) to fecal-contaminated water is gastroenteritis, which can result in nausea, vomiting, abdominal cramps, fever, headache, and diarrhea. Swimming in impacted waters can also lead to eye, ear, nose, skin, and throat infections and respiratory illnesses. In rarer cases, contaminated waters can lead to more serious conditions such as hepatitis, salmonellosis, or dysentery.

Management Practices to Reduce Runoff

Livestock manure is a valuable soil amendment and source of crop nutrients. However, manure that escapes from the application site can contaminate surface water and groundwater. Runoff from the farmstead, pastures and fields where manure has been applied can transport sediment, organic solids, nutrients and pathogens to surface waters. Tillage and manure management practices that quickly move manure into the root zone help to protect water quality and improve farm profitability by recycling valuable crop nutrients.

To help farmers deal with the problem of keeping manure from running off the land, the Natural Resources Conservation Service (NRCS), Michigan State University Extension (MSUE), and others suggest a wide variety of best management practices (BMPs) that can be implemented to reduce risks when storing, handling, or applying manure to land.

Identifying High-Risk Fields

When manure is applied to cropland it is important to identify the high risk areas in fields where runoff is likely to occur. These areas include sloping ground, fields adjacent to ditches and waterways, bottom land that tends to flood in wet weather, tile-drained land, and drained land with surface inlets. Vegetative filters, buffer strips and grass waterways have long been used to separate cropped or manure-applied land from nearby waterways. Widely used soil conservation practices that stabilize soil and prevent overland flow, runoff and soil erosion will help prevent manure contaminants from reaching waterways[5].

Cover Crops and Vegetated Filter Strips

When manure is applied to bare soil surface, nutrients and other contaminants accumulate at the surface and increase the chance of nutrient and bacterial transport in runoff water. But, when manure is applied to a vegetative surface, the plant biomass and organic matter filters bacteria and nutrients. Cover crops, grown in the field to protect the soil from wind and water erosion, to recycle nutrients, and improve soil structure and fertility, have been shown to be effective barriers for reducing overland flow, sedimentation and manure contamination of waterways[6]. Vegetated filter strips, consisting of planted or natural vegetation at the edge of a field or down-slope of pollution source areas also provide some protection by intercepting or trapping pollutants. Several studies have found complete or near complete removal of coliform bacteria with the use of vegetated buffer

strips[7],[8]. However, one study found that while grass buffer strips were 99% effective at trapping soil they were only 74% effective at capturing fecal coliform bacteria. That study, which used simulated rain on poultry wastes, concluded that grass buffer strips alone do not reduce bacterial concentrations sufficiently to meet water quality standards[9].

Managing Manure on Drained Cropland

Much of the productive cropland in the Great Lakes region contain drain tile for subsurface drainage. On some fields, however, land-applied manure can quickly enter sub-surface drains by preferential flow through macropores—large, continuous openings in soil formed by plant roots, cracks, earthworms and other natural processes. Manure, nutrients and contaminants that escape from application sites through sub-surface drains are not recycled in the cropping system and can degrade surface water quality. Tillage disrupts macropores, delays manure movement and can greatly decrease bacteria concentration in the effluent. Preferential flow to sub-surface drains is difficult to predict, but the following tips and facts may be helpful when addressing preferential flow and managing manure on tile-drained land[10]:

- Apply manure to dry ground and when no rain is forecast. Most problems occur on wet ground or in rainy weather.
- Use conservation tillage and cover crops to stabilize soil to help keep manure in the proper place.
- Monitor tile lines during manure application. Stop the application if any detectable odor or discoloration of effluent occurs.
- Apply at rates that do not cause manure transport. The allowable agronomic rate may not be the right application rate (few problems have been reported with rates less than 6,000 gallon/acre). Agronomic rates are based on manure nutrient content and annual crop nutrient requirements and not necessarily on the ability of the soil to process and retain the manure. With dilute manure slurries low in nutrients, the volume applied in one pass can be too high to be retained in the root zone.
- Be aware of the soil type. Fine-textured soils like clay loam and silt loam are more likely to have night crawler burrows that are direct conduits of manure contaminants than coarse-textured soils such as sandy loam.
- Discharge tiles to a holding pond or constructed wetland to help to decrease fecal bacteria. In a review of 135 constructed wetlands, the average wetland reduced fecal coliforms by 92%[11].

Because all fields are different, it is essential to learn the right application rate, the right amount of tillage, and the right way to manage each field. Land application of manures must receive the same attention to detail as the feeding and cropping programs.

Keep'em Out of the Stream

Prohibiting livestock from accessing streams and other surface waters is another effective way to reduce water pollution and also maintain stream habitat. Fencing off areas that have direct stream access keep livestock from trampling stream banks, increasing erosion, and destroying vegetation along the stream bank. It also prevents livestock from defecating directly into the water. Livestock exposure to water-transmitted diseases and foot rot will also be minimized. However, if the livestock relied on access to now barricaded surface water, an alternative water source is needed.

Other Practices and Considerations

A variety of other practices can reduce manure from moving into surface and ground waters including animal diet modification, pasture fencing, proper manure storage, and manure treatment including composting, anaerobic lagoons, anaerobic digestion, and chemical treatment[12]. Many of the BMPs described provide economic benefit to the operator and improvement in livestock performance. Cost share programs from state and federal agencies may also be available to implement practices.

Key Management Practices to Reduce Runoff to Streams

- Incorporate manure into soil
- Apply manure to relatively dry fields
- Avoid steep sloping areas
- Avoid areas near water bodies
- Avoid vulnerable locations for spreading manure
- Avoid areas prone to flooding
- Avoid applying on frozen soil
- Add buffer strips or grassed waterways
- Fence off stream access areas

Citations and Sources of Information

1-Dufour, Alfred P. 1984. Health effects criteria for fresh recreational waters. EPA-600/1-84-004. Office of Research and Development, USEPA, Washington, DC.
2-US EPA. 2008. Common Manure Handling Systems. Accessible at: http://www.epa.gov/oecaagct/ag101/dairymanure.html
3-Spiehs, Mindy and Sagar Goyal. 2007. Best Management Practices for Pathogen Control in Manure Management Systems. Minnesota Bulletin Number 08544, University of Minnesota, Minneapolis, MN. 10pp. Accessible at: www.extension.umn.edu/ distribution/livestocksystems/DI8544.html
4-Koelsch, Rick and Janice Ward. 2009. Best Management Practices (BMPs) to Prevent Manure Pathogen Movement to Water Resources. Accessible at: http://www.extension.org/pages/Best__Management__Practices__(BMPs)_to_Prevent_Manure_Pathogen_Movement_to_Water_Resources
5-Harrigan, T.M., W. Northcott, N. Rector and D. Bolinger. 2007. Keeping Land-Applied Manure in the Root Zone: Part 1: Sediment and Contaminant Runoff. Extension Bulletin WO-1036. Michigan State University, East Lansing, MI 48824.
6-Harrigan, T.M., D.R. Mutch and S.S. Snapp. 2006. Slurry-Enriched Seeding of Biosuppressive Covers. Applied Engineering in Agriculture 22(6):827-834.
7-Lim, T.T., D.R. Edwards, S.R. Workman, B.T. Larson and L. Dunn. 1998. Vegetated filter strip removal of cattle manure constituents in runoff. Trans. ASAE 41:1375-1381.
8-Sullivan, Timothy J., James A. Moore, David R. Thomas, et. al. 2007. Efficacy of Vegetated Buffers in Preventing Transport of Fecal Coliform Bacteria from Pasturelands. 2007. Environmental Management. Vol. 40(6): 958-965.
9-Coyne, M.S., R.A. Gilfillen, R.W. Rhodes, and R.L. Blevins. 1995. Soil and fecal coliform trappings by grass filter strips during simulated rain. J. Soil Water Conserv. 50: 405-408.
10-Harrigan, T.M. 2005. Manure on Tile-Drained Cropland. Michigan Dairy Review Vol. 10 (1): 10-12. Michigan State University, East Lansing, MI.
11-Knight, Robert L., Victor W. E. Payne, Jr., Robert E. Borerc, Ronald A. Clarke, Jr. and John H. Priese. 2000. Constructed wetlands for livestock wastewater management. Ecological Engineering. Vol 15(1-2): 41-55.
12-Pfost, Donald, Charles Fulhage, and David Rastorfer. 2000. Anaerobic Lagoons for Storage/Treatment of Livestock Manure. University of Missouri Extension, EQ 387. Columbia, MO. 8 pp.,

Other Source Information

GAAMPS. 2009. Generally Accepted Agricultural and Management Practices for Manure Management and Utilization. Michigan Department of Agriculture, Lansing, MI. 47pp. Accessible at: http://www.michigan.gov/documents/MDA_Manure_GAAMP_129695_7.pdf

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