1994

Agricultural Impacts on Fecal Contamination of Shallow Groundwaters in the Bluegrass Region of Kentucky

Mark S. Coyne
University of Kentucky, mark.coyne@uky.edu

J. M. Howell
University of Kentucky

UNIVERSITY OF KENTUCKY
COLLEGE OF AGRICULTURE
Lexington, KY 40546-0064

COOPERATIVE EXTENSION SERVICE

Department of Agronomy

Soil Science News & Views

Vol. 15, No. 6, 1994

Agricultural Impacts on Fecal Contamination of Shallow Groundwaters in the Bluegrass Region of Kentucky

M.S. Coyne and J.M. Howell

Introduction

Any farming practices that degrade water quality contribute to agricultural nonpoint source pollution. This is a problem in Kentucky's Bluegrass region where shallow soils and karst geology permit surface contaminants to reach groundwater quickly. Real and perceived threats to public health may make groundwater protection plans a reality if evidence for nonpoint source pollution in agricultural areas continues to grow.

Some of these contaminants are the fecal bacteria domesticated animals excrete. Though most fecal bacteria are harmless, animals can be reservoirs for pathogenic bacteria and viruses. Unfortunately, since nonpoint source pollution is so diffuse, except in a few streams, the level of fecal contamination in most individual watersheds isn't known. Even less is known about how typical agricultural management systems affect fecal contamination and whether it is reasonable to expect that changing management will also change contamination levels.

Table 1. Site characteristics and land use of the two study sites.

Location	*Major Land Use in 1992*	*% of Land*
Site 1 (1440 acres)		
	Tobacco	2
	Corn	15
	Soybeans	4
	Hay/Pasture	79
	400 beef cattle	
Site 2 (358 acres)		
	Tobacco	6
	Woods and miscellaneous use	10
	Hay/Pasture	84
	50 beef cattle	
	85 dairy cattle	

The likelihood that fecal wastes have contaminated water can be determined by looking for one type of bacterium that is nearly always associated with animal or human wastes- the fecal coliform. During a twelve month period in 1992 and 1993, we monitored a group of streams, wells, and springs in an agricultural watershed in the Inner and Outer Bluegrass regions of Kentucky. Our goal was to measure fecal coliform concentrations in typical agricultural water sources in these areas and relate them to land use management in the surrounding watersheds.

Study Sites

Study sites were watersheds with typical agricultural use for the Inner (site 1) and Outer (site 2) Bluegrass, respectively. Each site ultimately drains into a major creek and both sites represent typical land use management in the Bluegrass (Table 1). The underlying geology consists of interbedded limestone and shale, and the surface of both has karst topography. Lowell, Maury, and McAfee silt loam soils typify site 1 while Faywood and Lowell silt loams and Cynthiana silty clay loam typify site 2. These well-drained soils on undulating ridgetops, and moderately deep or shallow, well-drained soils on hilly uplands, were formed from the underlying limestone and shale residuum.

Sampling Methods

We sampled springs, streams, and wells at sites 1 and 2 weekly, when possible, from January 1992 to July 1992 and monthly from July 1992 to January 1993. Sampling was done on a predetermined day to prevent weather from biasing sample collection. We collected 500 mL water samples (about a pint) in sterile plastic bags and stored them at 39°F (4°C) until we could count the fecal coliforms. We counted these bacteria by filtering appropriate volumes of water onto sterile membranes that we placed on fecal coliform-specific growth medium. These filters were incubated for twenty-four hours at 112°F (44.5°C) after which we counted any colonies that had the color and shape characteristic of fecal coliforms.

Results

Some samples from all sample sites exceeded the Environmental Protection Agency (EPA) standard for primary contact water (200 fecal coliforms/100 mL at least part of the time. (Primary contact water means bathing and swimming water, 100 mL is about 3.5 fluid ounces). This is in contrast to the EPA standard for drinking water of less than 1 fecal coliform/100 mL. Some sites exceeded the standard most of the time (Table 2).

Springs (sources of shallow groundwater) in both locations were periodically free of fecal contamination. For example, as long as it was dry, the springs at site 2 remained free of fecal coliforms, even when cattle grazed the pastures around them. However, when there was a moderate rain, fecal coliforms in the springs rose to levels above the primary contact standard (Figure 1). Eighty percent of the samples exceeded the primary contact standard after cattle began grazing the pasture around site 2 springs 611 and 613. Only 19% of the samples exceeded the primary contact standard before cattle grazing began.

Two wells (shallow, hand-dug) in site 2 showed the importance of proper construction and siting. The average fecal coliform concentration in well 622 was 3240 fecal coliforms/100 mL. It exceeded the primary contact standard 74% of the time. Well 622 was a shallow, old style well, 10 to 15 feet deep, lined with creek rock. It probably received lateral flow from a heavily contaminated stream (#631) 20 feet away, that carried dairy waste from a parlor and feedlot to the main stem of the watershed drainage creek. Well 621 was newer, deeper (26 to 30 feet), cased in concrete, and at some distance from a stream. There were consistently fewer fecal coliforms in this well compared to the older one and it exceeded the primary contact standard significantly fewer times (nevertheless, there was a dairy loafing area above it, so the well still exceeded the primary contact standard about half the time we sampled it).

When cattle traffic in and next to streams, stream banks and bottoms may become significant bacterial reservoirs. The streams we sampled virtually always exceeded the primary contact standard since they either received cattle waste (as with stream 631) or else were directly accessible to cattle (as were the streams at site 1). Unlike springs, once streams were contaminated, they remained contaminated for months even after cattle stopped grazing around them.

Conclusions

Research in other states has shown that water sources in agricultural areas frequently exceed minimum water quality standards. Kentucky is no exception to that rule. Water quality in springs, streams, and wells frequently exceeded minimum contact standards for fecal contamination under typical land use management in the Bluegrass. Streams in particular, which afford grazing cattle direct access, were highly contaminated.

Although soil traps most fecal bacteria, surface deposited fecal bacteria still reached the shallow groundwaters we sampled in the well-structured soils containing many macropores in the karst topography of the Bluegrass region. However, until rain moves fecal bacteria through the soil profile, groundwater is relatively protected from fecal contamination. During the dry period between rains, fecal bacteria populations in the soil will rapidly decline. So, the longer the period between waste deposition and rainfall, the lower the amount of fecal contamination in groundwater.

Can anything be done to manage fecal contamination of groundwater? Cattle grazing management seems to have an effect. The most heavily contaminated water sources were those about which cattle continuously grazed. Once streams become contaminated, they stay that way for a long time. Keeping cattle out of streams would be an important step. If that is not possible, rotating them among grazed areas with greater frequency seems to help. At site 1, springs exceeded minimum water quality standards significantly fewer times when cattle grazed periodically, than continuously, around springs.

Kenneth L. Wells

Extension Soils Specialist

Table 2. Mean and maximum fecal coliform concentrations and the percentage of time springs, streams, and wells exceeded EPA primary contact water standards of 200 fecal coliforms/100 mL.

Location		*Number of Samples*	*% Exceeding Standards*	*Fecal coliforms/100 mL*	
				Mean	*Maximum*
Site 1					
Spring					
	511	30	23	246	4,000
	514	37	51	1,168	20,000
	516	36	28	325	4,000
	517	35	43	828	15,000
Stream					
	535	25	92	4,173	24,900
	536	31	87	3,807	21,050
Site 2					
Spring					
	611	28	61	920	9,300
	613	21	67	2,325	18,200
Stream					
	631	27	100	12,218	32,200
Well					
	621	18	56	595	4,000
	622	27	74	3,240	23,850

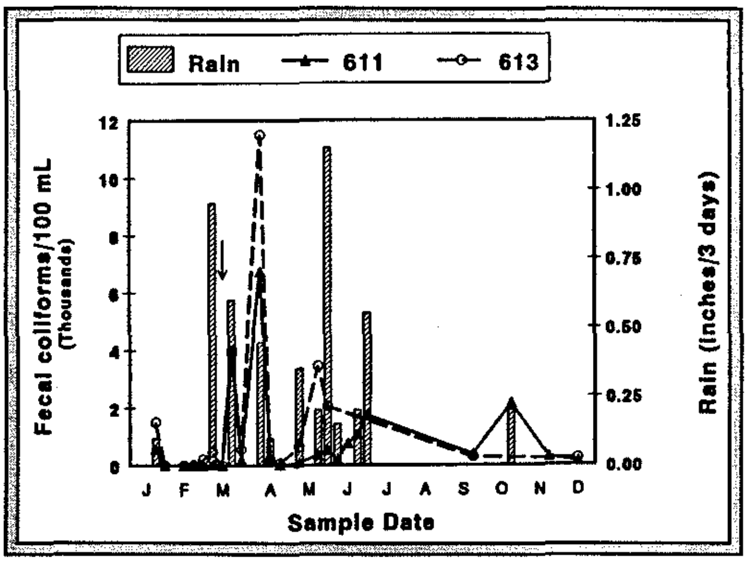

Figure. Fecal coliform concentrations in two springs at site 2 as influenced by rainfall and cattle grazing. Cattle were present at the site after the date indicated by the arrow. The bars indicate accumulated rain for a three day period including the sample date.

Kenneth L. Wells

Extension Soils Specialist