Fate and Transport of Surface Water Pathogens in Watersheds [Project #2694]

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OBJECTIVES:

This project was designed to advance the state of knowledge regarding sources, fate, and transport of pathogens such as *Cryptosporidium*, enteric viruses, and bacteria in drinking water catchments. Its principal goal was to facilitate the development of predictive models to describe expected concentrations of waterborne pathogens at critical downstream locations.

BACKGROUND:

Although pathogens such as *Cryptosporidium* oocysts present in animal fecal deposits on land, have been qualitatively and causally linked to event-related increases in pathogen concentrations in streams and reservoirs, there have been few attempts to quantify the relationship between pathogen dispersion and transport, rainfall, and surface water pathogen loads. Models that estimate sediment and nutrient export from land and predict the effectiveness of improved management practices are available. However, studies undertaken to date have not provided a similar basis for the prediction of pathogen exports. One of the major limitations is the lack of accurate data that is relevant to field conditions.

HIGHLIGHTS:

Major findings included pathogen inactivation rates on land and the water quality benefits of improved riparian buffer management, particularly the vegetative cover, which could be used to provide design criteria for setback distances to waterways. Pathogen transport in surface waters was quantified using artificial rainfall simulations over bare and vegetated soil at both laboratory and field-scale.

APPROACH:

A systematic approach was implemented for identifying the water industry's research priorities relating to pathogen fate and transport in catchments. A conceptual model of the relevant processes was developed, and the literature describing those processes was critically peer reviewed and published. Knowledge gaps were identified and considered within the context of the conceptual model. As a result of this review, the research focused on achieving the following objectives for three model fecal microorganisms (*Cryptosporidium*, *E. coli*, and adenoviruses) and their respective potential surrogates (*Clostridium perfringens* spores, *E. coli*, and PRD1 bacteriophages):

- Quantification in watershed sources to serve as measurable input functions to models for predicting downstream concentrations;
- Description of their attenuation as a function of organism characteristics and watershed-specific features (soil type, aggregation, and dispersal);
- Identification and quantification of the principal factors affecting their viability in feces and soil, as they transit to local surface water; and
- Description of the principal factors affecting transport of mobile pathogens passing across the terrestrial environment to local surface water.

The project examined pathogen concentrations and intrinsic "viabilities" of *Cryptosporidium* oocysts excreted by various domestic and native animals within a catchment as well as their inactivation in feces and soils. Culturable *E. coli* and the prevalence and types of infectious adenoviruses in animal feces were also described. Laboratory scale experiments were designed to examine the surface properties and aggregation/disaggregation of *Cryptosporidium* and the model virions (PRD1 and Adenovirus 2). Soil column studies with *Cryptosporidium* oocysts, *E. coli, Clostridium perfringens*, and PRD1 bacteriophages were used to described infiltration and exfiltration with selected soils. Small intact soil blocks were used in conjunction with an artificial rainfall maker to study the release and transport of *Cryptosporidium* oocysts from artificially inoculated fecal pats. Finally, calibration and ground-truthing was performed with a field-scale rainfall simulation system.

RESULTS/FINDINGS:

The prevalence of *Cryptosporidium* and *E. coli* in watershed animal feces and initial viabilities were quantified for cattle, sheep, pigs, and kangaroos. Next, data on *Cryptosporidium* and adenoviruses inactivation and dispersion was collected under controlled conditions for temperature, moisture content, and biotic activity in feces and soils. Lastly, the combined effects were investigated in pilot- and field-scale rainfall simulation experiments. The research team quantified the effect of vegetation versus bare soil in reducing pathogen transport particularly for *Cryptosporidium*. The data will facilitate the prediction of oocyst, *E. coli*, and enteric virus export to surface waters.

IMPACT:

The project provides quantitative data on the inactivation and transport rates of *Cryptosporidium*, *E. coli*, and viruses in fecal and soil matrices. This data facilitates the development of pathogen fate and transport models for drinking water watersheds. It also provides a guide to the effect of vegetation versus bare soil in reducing the overland transport of *Cryptosporidium, E. coli*, and viruses in surface waters. This information can be used as a guide for setting riparian buffer zones.

MULTIMEDIA:

The report package includes a CD-ROM. The CD-ROM contains the data from all of the experiments described in Chapters 2 through 7. In addition, it contains photos and videos of the lab-scale and field-scale rainfall simulation experiments described in Chapters 6 and 7.

PARTICIPANTS:

Research organizations and utilities from Australia and the Netherlands participated in this project.