WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: Developing A Risk-Based Approach To Watershed-Level, Non-Point-Source Modeling Of Fecal Coliform Pollution For Total Maximum Daily Load Estimates

Focus Categories:

Keywords: Nonpoint source, Fecal coliform, Water quality, Total maximum daily load

Duration: March 1, 1999 - February 29, 2000

Federal Funds Requested: $25,000

Non-Federal (matching) Funds Pledged: $50,000

Principal Investigators: Marty D. Matlock, Ph.D. Saqib Mukhtar, Ph.D.

Congressional Districts: Eighth (Texas)

Statement of Critical Regional Water Problem

The primary sources of pollution to the waters of the US are urban and agricultural runoff (EPA, 1994). The most common pollutants from these non-point sources are nutrients, bacteria, and silt (EPA, 1994). Agricultural land is most often used as the terminal receiver of animal waste. Thus, the persistence of potential microbial pathogens from wastes to soils and water is a consistent concern. Bacteria pathogenic to humans such as salmonellae, Campylobacter spp., Listeria monocytogenes, Eschericihia coli as well as others have been shown to survive in animal slurries for a considerable length of time (Jones, 1980; Kunte et al., 1998; Heinonen-Tanski et al., 1998). Consequently, the potential exists for the transmission of infectious diseases during land application of such slurries (Jones and Mathews, 1975; Ginnivan et al., 1980; Kudva et al., 1998; Kunte et al., 1998) as well from the runoff into streams and ground water (Kraft et al., 1969; Crane et al., 1983). Therefore, a risk analysis in the context of TMDLs for indicator organisms such as fecal coliforms is important in protecting human health in watersheds with complex land use and multiple bacterial pollution sources.

The Texas Natural Resource Conservation Commission (TNRCC) listed 148 stream segments in Texas as not meeting their designated use under the Clean Water Act, subsection 303.d (TNRCC, 1998). Bacterial contamination is listed as a pollutant of concern in 65 of these segments (TNRCC, 1988). Coliform bacteria are a collection of relatively harmless microorganisms that live in large numbers in the intestines of animals. Fecal coliforms, a subgroup of these bacteria, can grow at elevated temperature, and include bacteria such as Eschrichia coli. The presence of fecal coliform bacteria in aquatic environments is used by the US Environmental Protection Agency (EPA) and TNRCC as an indicator that water bodies have been contaminated with fecal material.

This contamination may result in exposure of humans and wildlife to harmful pathogens such as typhoid fever, or viruses such as hepatitis A, among others. While the methods used to measure fecal coliform bacteria are prone to interferences, they are the most cost-effective and practical methods available, and are not likely to change in the immediate future (APHA, 1990).

Controlling nonpoint source (NPS) bacteria is complicated by the nature of the pollutant - a loading approach is not appropriate since the organisms may be able to reproduce and grow in the stream. Our ability to manage and control bacterial pollution is dependent upon our ability to quantify bacterial survival and reproductive capacity in aquatic ecosystems (Cairns and McCormick, 1991). The factors that influence NPS bacterial contamination include land use, soil characteristics, climate, topography, and land management practices (Beaulac and Reckhow, 1987). Estimates of bacterial contamination from specific land use practices exhibit considerable uncertainty, making temporal and spatial modeling of water quality based solely on land use difficult (Beaulac and Reckhow, 1982). We are only recently beginning to quantify these sources of uncertainty, and incorporate them into pollution prediction models (Hession et al., 1995). In order to manage bacterial contamination to rivers and streams and predict the effects of that contamination we must improve our ability to quantify the uncertainty of our predictions.

Results Expected from this Project

This project will be integrated with a larger nutrient management project in the San Antonio River basin funded by US-EPA, NSF, and USDA under the Watershed Restoration Program (WRP). The WRP project is designed to develop critical nutrient loading rates and control strategies as part of a risk-based approach for establishing total maximum daily loads (TMDLs) in Leon and Salado Creeks in the San Antonio River Basin.

A risk-based model will be developed and integrated into the Hydrologic Simulation Program-Fortran (HSPF), a continuous process based pollutant transport and fate model. This model will be integrated into Better Assessment Science Integrating Point and Nonpoint Sources (BASINS), and will be used to determine how much of a given pollutant a water body can assimilate without degradation of ecological services. The next step in reducing NPS bacteria contamination is to identify the sources within the watershed and characterize the pollutant-reduction potential of each source. We will evaluate and validate the model with monitoring data available from the San Antonio River Authority. The risk of exceeding some TMDL based on current land-use practices will be quantified by propagating uncertainty using Monte Carlo simulation.

The results from this project will allow investigators to optimize best management practice (BMP) options for reducing fecal coliform contamination. The risk-based nutrient TMDL strategy developed by this project will provide a format for bacteria TMDLs throughout the south-western region. We expect the proposed research to add significantly to our understanding of the response of aquatic ecosystems to urban and agricultural bacteria loading. We will prepare a proposal for funding from USDA and EPA in 1999 based o the results of this work.

Research Objectives

The objective of this project is to develop a risk-based approach to watershed-level total maximum daily loads (TMDLs) for fecal coliform bacteria in the south-western United States. This approach will provide a scientifically sound model for predicting point and non-point sources of fecal coliform bacteria within agricultural and urban watersheds. Our strategy is to quantify and reduce the uncertainty associated with watershed-level modeling of bacterial fate and transport. Reducing each source of uncertainty associated with bacterial TMDLs will result in their increased application for watershed-level pollution control, a concurrent reduction of bacterial contamination to our nation's waters, and reduction in the costs of achieving an acceptable level of environmental quality. The specific objectives of our research project are:

1. Develop a strategy for assessing risk associated with exceeding some critical contaminant level of fecal coliform bacteria under the TMDL approach developed by EPA;

2. Validate a risk-based model of fecal coliform deposition, growth and persistence in aquatic ecosystems.