Development of Regression-Based Models to Predict Fecal Bacteria at the Illinois River Basin, Arkansas and Oklahoma

Morgan David[1], Brian Haggard[1,2]

[1]Department of Biological and Agricultural Engineering, University of Arkansas, 203 Engineering Hall, Fayetteville, Arkansas 72701 USA

[2]Department of Crop, Soil and Environmental Sciences, University of Arkansas

Introduction

- The USDA NRI, for the 2006 fiscal year, identified the funding priorities for the water and watersheds program to "*understand the source, fate and transport of pathogens such as bacteria, protozoa and viruses in soil and water systems*."
- The Illinois River Basin is a multi-facet watershed with ecological and economical importance to Northwest Arkansas and Northeast Oklahoma, where catchment land use has changed over the last several decades with increased agricultural and urban growth.
- Evaluation by hydrograph separation, and subsequently synthetic model development, will identify the relationships between fecal bacteria and the other measured physico-chemical parameters across selected sites and between flow regimes (i.e., base flow conditions and surface runoff events).
- This area has been under the national spotlight because of an environmental lawsuit initiated by the state of Oklahoma against several poultry companies based in Northwest Arkansas.

Methods

- The USGS NWIS database provided archived data from October 1, 1995 through September 30, 2003 for the selected sites; the archived data was downloaded from the following state-specific (AR and OK) websites: http://waterdata.usgs.gov/
- Base Flow Index (BFI Model) was used to separate the water quality data, for each site, by flow parameters: base flow and surface runoff.
- By our definition, a base flow sample was collected when base flow discharge is greater than or equal to 70% of mean daily discharge (total stream flow) and a surface runoff sample was collected when base flow discharge was less than 70% of the total stream flow.
- The various physico-chemical parameters were compared and contrasted with bacteria (i.e., fecal coliform, E. coli, and fecal streptococci) at the base flow, surface runoff, and combined flow conditions. (See below.)

Physicochemical properties: pH, dissolved oxygen, specific conductance, temperature

Nutrients: dissolved calcium, dissolved chloride, dissolved magnesium, nitrogen ammonia, nitrogen ammonia plus organics, nitrogen nitrite dissolved, nitrogen nitrite plus nitrate, phosphorus dissolved, phosphorus orthophosphate, phosphorus total, dissolved potassium, dissolved sodium, dissolved sulfate

Sediments: sediment suspended sieve, sediment suspended, solids residue

- A synthetic model, developed as part of this project, will identify the relationships between fecal bacteria and the other measured physico-chemical parameters across selected sites and between flow regimes.
  - ➢The goal will be to predict daily bacteria concentrations.

Objectives

- Obtain fecal bacteria and related constituent data for the Illinois River and surrounding Ozark streams from the USGS NWIS database.
- Evaluate relationship between fecal bacteria concentration and several associated constituents during different discharge regimes.
- Predict daily fecal bacteria concentration in Illinois River Basin based on an outlined synthetic approach considering two different flow regimes: base flow conditions and storm events.

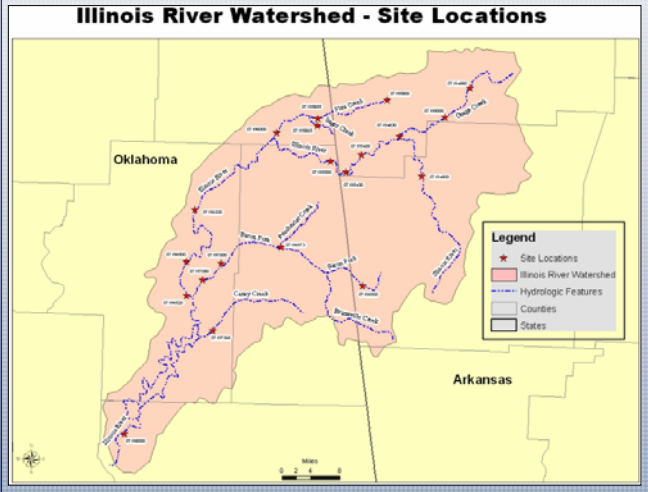


Figure Depicting Study sites in the Illinois River Basin in Northwest Arkansas and Northeast Oklahoma identified by the geographical coordinates (NWIS, 2007).

Figure Above Depicts Base Flow Conditions. Note the Stream Bank and the Depth of Water Compared to the Trees.

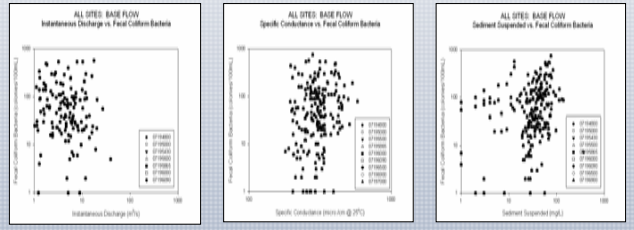
Figure Below Depicts Storm Event Conditions at the Baron Fork. Note the Flooding of the Stream Bank and the Depth of Water Compared to the Trees.

Figures Depicting Base Flow and Surface Runoff Conditions at the Baron Fork Creek at Eldon, Oklahoma In the Illinois River Watershed During 2001.

Preliminary Analyses

- Fecal coliform concentrations varied by date and between sites, where 13% and <1.0% of the fecal coliform samples exceeded 200 colonies/100mL and 1000 colonies/100mL, respectively, during base flow conditions.
- Fecal coliform concentrations were significantly correlated with instantaneous discharge, specific conductance, and sediment suspended during each flow regime; however these parameters did not explain much of the variation in fecal bacteria.

Figures Depict Correlation Between Fecal Coliform Bacteria and Instantaneous Discharge (left), Specific Conductance (middle), and Sediment Suspended (right) at Base Flow Across All Stream Sites.



Figures Depict Correlation Between Fecal Coliform Bacteria and Instantaneous Discharge (left), Specific Conductance (middle), and Sediment Suspended (right) at Surface Runoff Across All Stream Sites.

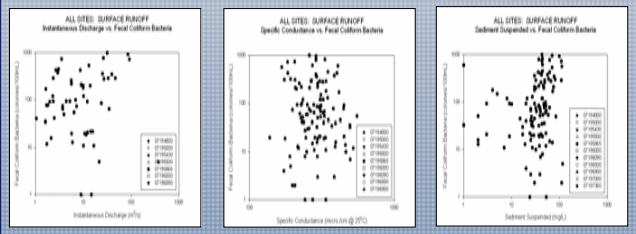


Table Provides R^2 and P Values for Base Flow and Surface Runoff Conditions Between Fecal Coliform Bacteria and Instantaneous Discharge, Specific Conductance, and Sediment Suspended Parameters.

	Base Flow			Surface Runoff		
	Instantaneous Discharge	Specific Conductance	Sediment Suspended	Instantaneous Discharge	Specific Conductance	Sediment Suspended
P	<0.0001	0.0356	0.0041	<0.0001	0.0614	<0.0001
R^2	0.1823	0.0221	0.0390	0.3207	0.0645	0.6881

What's Next?

- Individual evaluation of the 11 sites within Arkansas and Oklahoma during base flow and storm event conditions.
- Development of a synthetic model providing a useful tool to easily predict fecal bacteria concentrations in this watershed in the future.