Evaluation of Risk-Based Water Quality Sampling Strategies for the Fresh Produce Industry

RESEARCH COMPLETED

SUMMARY

The quality of irrigation water plays a significant role in the occurrence of outbreaks associated with fresh produce. As a result, the FDA released the Food Safety Modernization Act (FSMA) Produce Safety Rule (PSR), which is a set of guidelines that specify water quality sampling requirements for indicator bacteria (*Escherichia coli*) and sampling frequency. This study aimed to assess and quantify factors relating to the PSR rule, including the variability of indicator bacteria and pathogens in irrigation water over time, as well as the impact of risk factors (e.g., rainfall, temperature, canal size) on overall water quality. The study led to the development of a risk model for irrigation water quality based on environmental factors. The risk model feeds into a user-friendly app, titled Ag Water, that offers sampling advice and predicts water quality in real-time based on historical data, weather information, and environmental parameters.

OBJECTIVES

This research study aimed to assess and quantify:

- The variability of *E. coli*/*Salmonella* occurrence in irrigation water over time, based on historic and recently collected data
- The impact of risk events and factors, such as rainfall, temperature, canal size and watershed characteristics, on the occurrence of organisms in irrigation water
- The impact of occurrence, duration and intensity of rainfall events on *E. coli*/*Salmonella* levels to determine the time interval for which irrigation water quality is impacted
- A risk-based model for *E. coli*/*Salmonella* in irrigation waters based on environmental factors, irrigation methods, and type of produce
- Risk-based sampling advice in the form of a mobile/web-based app, used for guidance on sampling frequency after high-risk weather events and to help growers maintain compliance with FSMA PSR regulations

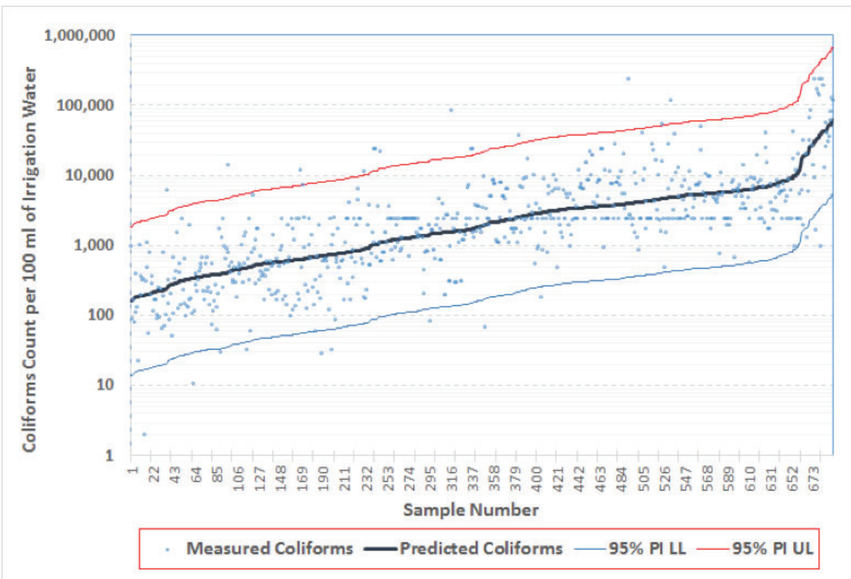
METHODS

Over the course of this study, datasets were gathered from irrigation canals in Yuma and Maricopa, AZ and Imperial Valley starting in 2001. The datasets have measurements of *E. coli* and coliform counts per 100 ml of irrigation water and physical characteristics of the irrigation water. Each region's dataset was analyzed separately to arrive at a regional model for prediction of *E. coli* and coliform bacteria.

This historical data was used to determine the relationship between irrigation water physical parameters and Coliform/*E. coli* counts. Water physical parameters assessed include: coliforms, *E. coli*, tw (water temperature), pH, turbidity, and electrical conductivity. Using the transformed data and associated correlations, the research team was then able to build a set of models (n=13) that could be used to predict water quality conditions related to coliform counts or the presence of *E. coli* bacteria.

Figure 1: Complete Model: Predicted Coliform Counts vs. Measured Coliforms for the Yuma Area with 95% Upper and Lower Prediction Limits*

[*Figure 1 depicts the complete model of predicted coliform bacteria (dark blue line) when compared to measured coliform counts (from low to high concentrations of *E. coli*) within 95% confidence intervals (red and light blue lines). It is easily seen that the model predicts accurate bacterial numbers within the assigned confidence interval with very few outliers present.]



RESULTS TO DATE

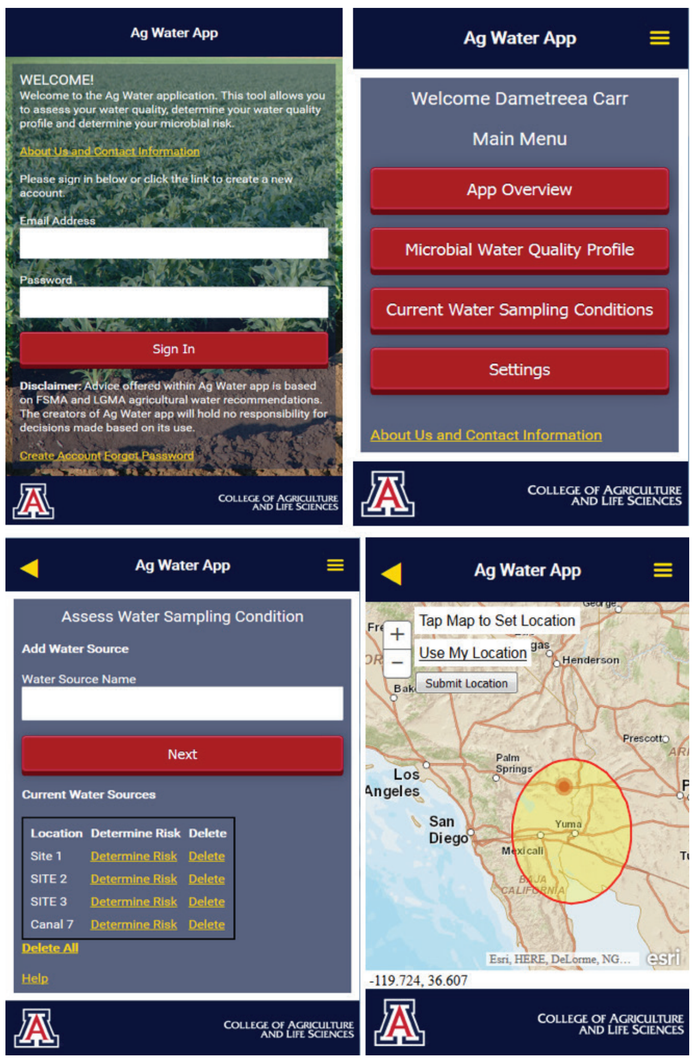
- Water quality is highly dependent on localized environmental conditions, and effort should be made by industry to better understand their water sources through collection of water quality data and historical analysis.
- Main influential factors in the region evaluated were air temperature, solar radiation, rainfall and electrical conductivity (EC). The ability of a user to input electrical conductivity into developed models greatly increased risk assessment confidence. This lends itself towards the recommendation to industry to include EC in routine water quality monitoring plans to increase the likelihood of predicting coliform bacteria and *E. coli* in water sources.
- There is no "one-size fits all" model to predict water quality, however, the complete model developed by our research team provides accurate predictions of water quality based on the data available and the region evaluated.
- Grower apps can be useful tools that allow industry to make more informed decisions about their water sources from both a water use and sampling perspective.

BENEFITS TO THE INDUSTRY

Every year 48 million Americans (1 in 6 people) contract a foodborne illness as a result of ingesting pathogen contaminated foods. With irrigation water quality being a contributing factor to produce contamination, it is important that industry be equipped with useful tools and information to reduce outbreaks and protect the public's health. The results of this study benefit industry by:

- Verifying produce safety guidelines as set by the FDA
- Determining the duration of effects of high-risk weather events on irrigation water quality
- Assisting growers with water sampling activities and making recommendations based on predictions using historical weather data, physical parameters, and user data input
- Providing growers with an easy-to-use app that will save them time and help maintain compliance with the FSMA PSR

Figure 2. AgWater App User Interface



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