Project Information Summary

Unlocking the Nationwide Potential of Water Reuse: Task B (5197B)

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Project Duration: 44 months

Total Project Value: $5,356,929

Goal and Objectives

Task B aims to develop an integrated water reuse treatment plant (WRTP) Model and an advanced process control system through three main objectives:

1. Develop robust models for individual and combined treatment processes relevant to water reuse that result in predictions of process performance (i.e., predictive algorithms)
2. Integrate predictive algorithms into a comprehensive model that allows for a systematic treatment train evaluation for achieving microbial and chemical water quality goals while also considering cost
3. Pilot-scale demonstration and technoeconomic analysis (TEA) of predictive machine learning algorithms for real-time risk mitigation of common and advanced reuse treatment processes.

Background and Motivation

The recent adoption of the national Water Reuse Action Plan (WRAP) by the United States Environmental Protection Agency (USEPA) has energized an effort to support the consideration and adoption of water reuse at a national scale. Unlocking and realizing the full nationwide potential of water reuse will require an integrated research plan and development of tools to encourage and support increased adoption of water reuse.

Task B research will facilitate sustainable solutions for expanding the nationwide water reuse portfolio by developing data driven models, which will allow for robust treatment evaluations (even during the early design phases) and application of the models and information to elucidate the entire landscape of water reuse potential across the United States. These data-driven models—validated by experimental results from pilot and full-scale evaluations—will improve the monitoring and control of water reuse systems and lessen the need for highly conservative (and sometimes unsustainable) strategies focused on ensuring removal of constituents that may not even be present in the source water. By producing models calibrated for use with different influent water qualities and sufficiently precise real-time control and fault prediction, the proposed research will facilitate the robust evaluation of a full range of fit-for-purpose water reuse scenarios.

Research Approach

Task B1 - Develop Predictive Algorithms

1. Collection of data resources and assessing existing algorithms, including finalizing the treatment processes and constituents to be evaluated.

2. Update existing predictive algorithms and develop new ones by applying the existing drinking water-based predictive algorithms (typically nonlinear) to the water reuse data and assessing predictive performance relevant to water reuse.
3. Evaluate how changes in water quality in distribution systems affect development of corrosion and opportunistic pathogens; create algorithms to help identify these specific conditions.
4. Assess the formation and decay of disinfection byproducts (DBPs) in the distribution system using predictive drinking water condition formation algorithms to predict DBPs under water reuse conditions.
5. Generate additional data through bench-scale laboratory experiments and from our project pilot plants for processes known to be data-poor.

Task B2 - Water Reuse Treatment Plant (WRTP) Model Development

1. Integrate predictive algorithms developed in Task B1 into a comprehensive model using the drinking water-based water treatment plant model platform to create WRTP Model.
2. Validate the WRTP model using water quality and design/operating data and process train performance data from the pilot plants and our partner utilities.
3. Utilize the USEPA open access cost model for water treatment processes, incorporating design and operating conditions as input to calculate the capital and operating costs of water reuse scenarios.

Task B3 - Online Monitoring and Control as Risk Mitigation Techniques

1. Operate the mobile direct potable reuse (DPR) demonstration lab pilot-scale treatment processes for data collection at 4 to 6 locations over a two-year period, representing different geographic regions, community sizes, and reuse challenges.
2. Implement real-time prediction and optimization at pilot-scale, using extensive monitoring and machine learning to validate and challenge the models, and evaluating process stability and reliability at a range of environmental and operational conditions.
3. Use TEA to evaluate the cost benefit of incorporating technical and economic data into a comprehensive control system that can be optimized to maximize the efficiency of the system for fit-for-purpose water reuse systems.

Deliverables

- A WRTP model with modules on trace organic contaminant control and distribution system water quality, including capital and operating cost evaluation.
- Data and analysis from operation of a DPR pilot system across numerous utilities and reuse opportunities.
- TEA of an integrated control system allowing for real-time decision making informed by machine learning.

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