Environmental Engineering

UNIVERSITY OF COLORADO **BOULDER**

PhD Thesis Defense

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Improving Multi-objective Sustainability at Small Drinking Water Systems: Modelling & Decision-support

Date: Monday, April 1st, 2019
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Place: SEEL 303
Faculty Advisor: Professor Sherri Cook

Abstract:

Small drinking water systems represent 95% of drinking water systems in the United States, but they often face technical, managerial, and financial challenges, which are exacerbated when making treatment decisions. Furthermore, the treatment decisions that small systems must make will become more difficult as regulations become more stringent and source water quality degrades due to population growth and anthropogenic pollution. Previous work has not effectively provided decision support that is widely relevant to the tens of thousands of small drinking water systems that require decision-making assistance. The objectives of this dissertation were to: assess the relative environmental impacts of filtration and disinfection processes, relevant to small systems, that have theoretical benefits (e.g., reducing chemical use); construct a decision making tool that navigates trade-offs between sustainability dimensions to provide a small system stakeholder with custom, final recommendations; and provide insights on treatment selection that are applicable for a wide range of source water qualities, stakeholder preferences, and regulatory requirements while considering design uncertainty. Life cycle assessment was used to quantify the environmental impacts resulting from filtration and disinfection treatment processes. For filtration processes, the results showed that conventional filtration was more environmentally preferred for more pristine source waters, and biological filtration was more preferred when the source water was more degraded and treatment requirements were more stringent. For disinfection processes, chlorine was environmentally preferred to ultraviolet disinfection in most cases, but ultraviolet disinfection was preferred when its Cryptosporidium reduction benefits could be realized. Life cycle assessment and multiple-criteria decision analysis methods were used in unison to construct a comprehensive and rigorous decision-making tool for small systems. The tool is universal in its ability to provide small systems with insights for making a treatment decision under distinct source water qualities, stakeholder preferences, and regulatory requirements while considering design uncertainty. The tool was used to evaluate 60,000 diverse simulated small systems. Results indicated that treatment alternative recommendations changed to suit diverse small drinking water systems and that filter selection effects the recommendation of a treatment train more than other treatment processes. Ultimately, different stakeholder groups (e.g., consumers, engineers, operators, and regulators) can gain insights, using site specific characteristics, to make sustainable decisions while improving drinking water quality.

Christopher "Topher" Jones is a PhD candidate at the University of Colorado Boulder who received his B.S. at California Polytechnic State University in San Luis Obispo. Topher is interested in researching the sustainability of drinking water systems quantitatively using environmental and social criteria that are not traditionally considered.