Public water systems add disinfectants in water treatment to inactivate microbial pathogens. Chlorine, when used as a disinfectant, reacts with natural organic matter in water to form trihalomethane (THM) and haloacetic acid (HAA5) disinfection by-products (DBPs), which are suspected carcinogens. The Safe Drinking Water Act's Disinfectant and Disinfection By-Product (D/DBP) Rules were promulgated by the U.S. Environmental Protection Agency to regulate the amount of DBPs in water systems. Regulatory compliance is based on maximum contaminant levels (MCL), measured as a locational running annual average (LRAA), for total THM (TTHM) and HAA5 of 80 µg/L and 60 µg/L, respectively. Regulated DBPs, if consumed in excess of EPA's MCL standard over many years, may increase chronic health risks.

In order to comply with the D/DBP Rules, the County of Maui Department of Water Supply (DWS) adopted two DBP control technologies. A GridBee® spray-aeration process was placed into DWS's Lower Kula water system's Brooks ground storage tank in February of 2013. In March of 2015 the second DBP control technology, granular activated carbon (GAC), was integrated into DWS's Pi'iholo surface water treatment plant. To investigate the integration effectiveness of GAC and spray-aeration into a water system for DBP control, DBP data was gathered from the system between August of 2011 and August 2016, and analyzed relative to cost and performance.

Prior to the spray aeration and GAC integration, it was found that TTHM levels at the LRAA compliance site ranged between 58.5 µg/L and 125 µg/L (at times exceeding the MCL). Additionally, HAA5 levels at the LRAA compliance site ranged between 21.2 and 52.0 µg/L. The concerted efforts of the GAC and GridBee® system was found to reduce LRAA TTHM and HAA5 concentrations to 38.5 µg/L and 20.5 µg/L, respectively, in the Lower Kula system. Hypothesis testing utilizing t-Tests confirmed that TTHMs levels were controlled by the spray aeration system and the GAC was responsible for controlling HAA5 formation. Although TTHM levels were reduced by 58 percent, and HAA5 levels by 48 percent, the estimated cumulative annual operation and maintenance (O&M) cost of the two systems was $1,036,000.

In light of the cost analysis, total organic carbon (TOC)-based models for predicting LRAA TTHM and HAA5 levels were developed. The TTHM model yielded an R² of 0.93, and the HAA5 model had an R² of 0.52. F-Tests comparing predicted LRAA TTHM and HAA5 levels to actual LRAA TTHM and HAA5 levels determined no statistically-significant difference. With the knowledge of how the GAC and spray aerator controlled DBPs in the water system, a cost-effective and practical treatment operating parameter was developed. The parameter, Pi'iholo water plant filter effluent TOC content, can serve as an indicator that operators would use to alter DBP treatment process flow set points to achieve cost-effective treatment. Furthermore, the significant annual cost contribution by the GAC, coupled with HAA5 levels below DWS's MCLG, led to the recommendation of variable frequency drive (VFD) pumps for the GAC system to reduce the frequency of carbon change outs.

Major: Environmental Engineering

Educational Career:
Bachelor's of Environmental Engineering, BS, 2015, University of Central Florida

Committee in Charge:
Steven J. Duranceau, Chair, Civil, Environmental and Construction Engineering
Woo Hyoung Lee, Professor
AHM Anwar Sadmani, Professor
Approved for distribution by Steven J. Duranceau, Committee Chair, on August 22, 2016.

The public is welcome to attend.