Enhanced Pathogen Reduction of Urban Wet Weather Flows

BACKGROUND

As part of its program to help protect the quality of urban waterways and Lake Erie, the City of Toledo operates up to 776-ML/d (205-mgd) of auxiliary treatment facilities in parallel with up to 738-ML/d (195-mgd) of conventional nitrifying activated sludge facilities to treat peak wet-weather flows from its combined stormwater and wastewater collection system (see Figure 1). The auxiliary treatment facilities consist of bar screens, vortex grit removal units, chemically enhanced high-rate clarification, effluent chlorination, reaeration, and dechlorination.

A two-year performance study of the auxiliary facilities was completed in accordance with USEPA requirements and confirmed the effectiveness of the new facilities during 29 wet-weather events that occurred over the testing period (Black & Veatch, 2009). Subsequently, the USEPA requested that the City further evaluate the reduction of pathogens across both treatment trains. This applied research is one of the first of its kind among municipal water reclamation utilities due to the following:

- The large scale of both treatment trains,
- Performance monitoring during peak wet-weather flows,
- Parallel treatment with enhanced high-rate technologies, and
- Monitoring of pathogenic bacteria, protozoa and viruses in addition to conventional indicator organisms.

OBJECTIVES

The study compares and contrasts pathogen removal and inactivation by the auxiliary high-rate clarification (HRC) train and the activated sludge (AS) train when conditions meet the following qualifications:

• Events have sufficient precipitation to cause simultaneous discharge from both the HRC and AS trains for a period of at least six hours, and

• Events occur during the facility's effluent disinfection season (April 1 - October 31).

METHODOLOGY

Precipitation and flow meter records from the facility were reviewed to confirm qualifying conditions for each event. Samples of (A) influent, (B) pre-chlorination effluent and (C) post-dechlorination effluent were collected bihourly from each treatment train during each qualifying event. Each sample was analyzed for the following parameters:

• Pathogenic microbes - Campylobacter, Salmonella, Cryptosporidium, Giardia and adenoviruses

• Indicator organisms - fecal coliforms, Escherichia coli, enterococci, somatic coliphage and male-specific coliphage

• Conventional parameters - pH, total suspended solids, and 5-day biochemical oxygen demand

• Other parameters - turbidity, dissolved oxygen, total residual chlorine, total dissolved solids, chemical oxygen demand

The study team worked with USEPA to develop a Field Sampling and Quality Assurance Project Plan (QAPP) to generate data that would yield valid comparisons between the two treatment trains and meet the study objectives. Sampling and laboratory analyses generally followed USEPA-approved methods listed in the Code of Federal Regulations (40 CFR 136) for activities regulated by the National Pollutant Discharge Elimination System (NPDES). Analytical methods for three of the parameters are currently not listed in 40 CFR 136, but were analyzed by the following methods:

1. Adenoviruses - EPA Method 600/4-84013(N14); SOP; Cell Culture for Infection by Virus, Q-PCR.

2. Campylobacter - Centrifugation, Enrichment, Isolation, PCR

3. Coliphages - EPA Method 1602

STATUS

Since the study began in 2011, five events have met the qualifying conditions and four of those events were sampled and analyzed. One event occurred within the 60-day “reset period” required to complete the laboratory analysis for adenoviruses and prepare for the next sample event. The USEPA originally requested that the study consist of data from 10 qualifying events; however, the City plans to review the data with USEPA in the spring of 2016 to determine if 10 events will ultimately be required.

FINDINGS

Other studies (Rose et al., 2005; Wu et al., 2011) have suggested that the fate of pathogenic microbes through treatment processes may not correlate well with the fate of commonly used indicator organisms. Aggregate results from this study tend to support those findings.

No statistically significant differences between the two treatment trains were detected in the reduction efficiencies for many of the analytes (see Figure 2 Salmonella results for example). Both the activated sludge train and HRC train provided statistically significant reductions in indicator bacteria, indicator viruses and conventional pollutants.

The HRC train statistically reduced Campylobacter, Cryptosporidium and Giardia slightly more than the AS train (Figures 2, 3 and 4). The TSS and turbidity data indicated that the HRC train also provided slightly more removal of particulate matter than the AS train, which further suggests similar or better removal of protozoan cysts through the HRC train compared to the AS train.

The AS train statistically reduced coliphage and enterococci more than the HRC train; however, the design and operation of the effluent disinfection facilities were optimized to reduce E. coli in compliance with the current NPDES permit, not the alternate indicators (coliphage and enterococci). Significant design and operational changes would likely be necessary to optimize disinfection performance around the alternate indicators; therefore, firm conclusions regarding the efficacy of effluent disinfection for coliphage and enterococci were beyond the scope of this study.

RELEVANCE

For over a decade now approximately 30 POTWs in the U.S. (approximately 100 worldwide) have operated advanced auxiliary treatment facilities similar to those in Toledo to consistently produce significantly better effluent quality than the standard technologies traditionally used in this application (i.e. primary clarification equivalency). These advanced technologies have recently been collectively termed enhanced high-rate treatment (EHRT) and generally involve some variation of chemically enhanced settling, dissolved air flotation or a filtration process along with an effluent disinfection process.

Data from these EHRT installations demonstrate that, for all practical purposes, disinfected EHRT effluent quality is equivalent to that from conventional secondary treatment technologies when treating peak wet-weather flows, particularly with respect to the efficiency and reliability of effluent disinfection processes. In many cases, capacity expansions with EHRT technologies are more affordable than other alternatives for wet-weather flows and stormwater. Therefore, EHRT deserves a different regulatory classification than being pigeon-holed into the same category as traditional “bypass” or “blending” technologies. Furthermore, the U.S. Eighth Circuit Court recently referred to EHRT technologies as “non-biological peak flow secondary treatment processes” in their decision upholding the practice of peak wet-weather flow blending (Iowa League of Cities v. EPA, March 2013).

NPDES permitting policies and frameworks should be updated to better keep pace with these technology advancements. Existing Clean Water Act regulations (40 CFR 122 and 133) appear to have the flexibility to further legitimize EHRT technologies as “auxiliary treatment” facilities within the codified definition of “secondary treatment”. This flexibility is likely to become more important as integrated wastewater and stormwater utility plans gain momentum and become implemented, particularly for densely populated urban areas. In fact, some utilities challenged with water scarcity are considering these same EHRT technologies to increase stormwater reuse instead of discharging it to surface waters or marine environments.

NOTE: Keep references, tables/images, and author information in separate sections as they are uploaded into different portions of the submittal system. None of these if kept separate will count towards your word limit.

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References: 40 CFR 133, Secondary Treatment Regulation, Code of Federal Regulations.

40 CFR 122, EPA Administered Permit Programs: The National Pollutant Discharge Elimination System, Code of Federal

Images/Tables:

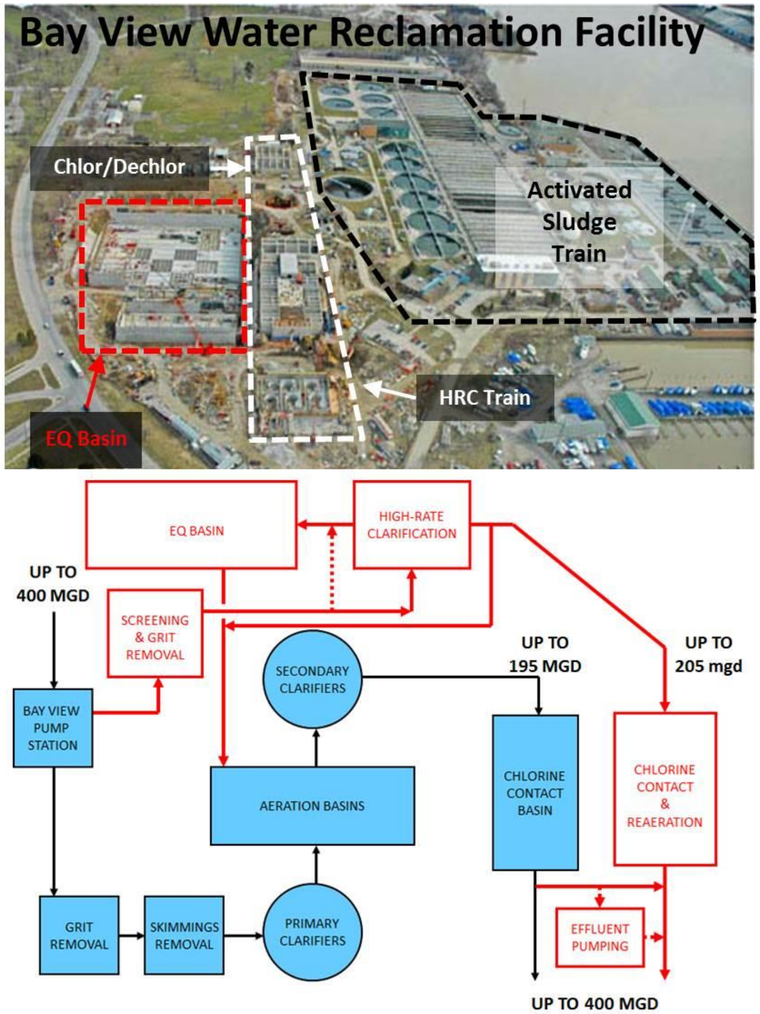

Figure 1. Since commissioning its auxiliary HRC facilities in 2006, the City of Toledo, Ohio has treated up to 1514 ML/d (400 mgd) of combined stormwater and wastewater during peak wet-weather events.

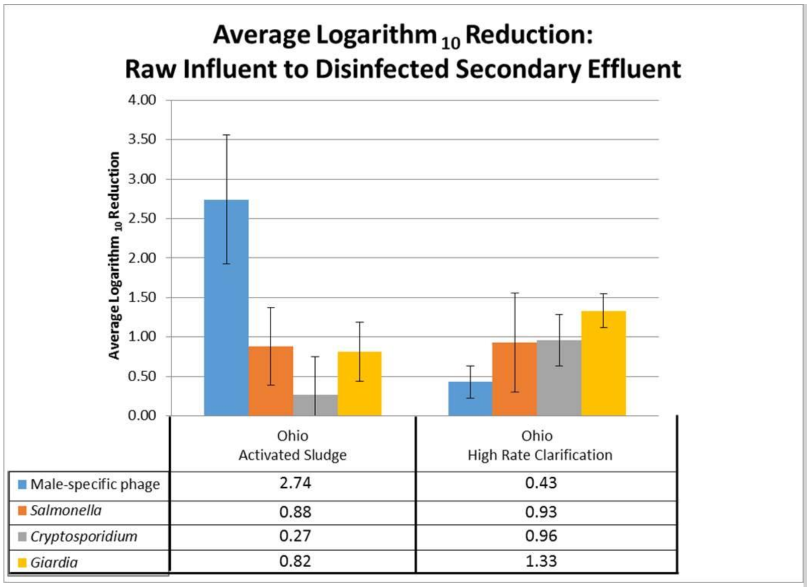

Figure 2. Compared to the AS train, the HRC train removed similar amounts of Salmonella, more *Cryptosporidium* and *Giardia*, and less male-specific phage (an indicator organism).

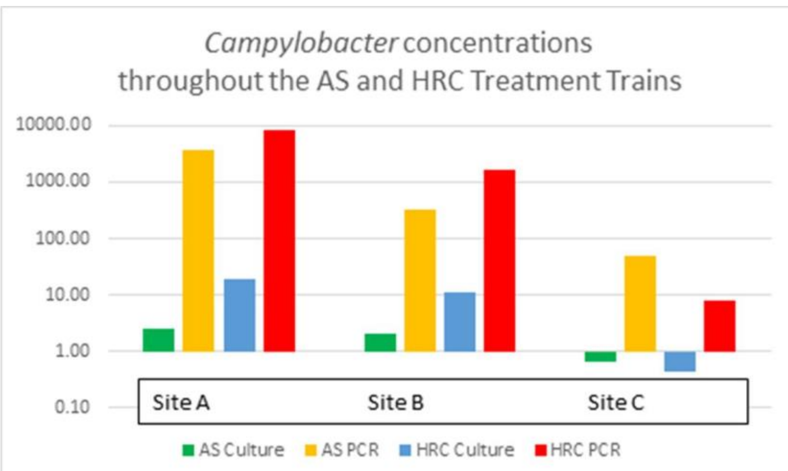

Figure 3. The study results suggest that the HRC train was also superior to the activated sludge train for reduction of *Campylobacter* from wet-weather flows. (n=9 for each sampling method and train, triplicates and three sampling dates: 13 Jun 2013, 10 Sep 2014, 31 May 2015)

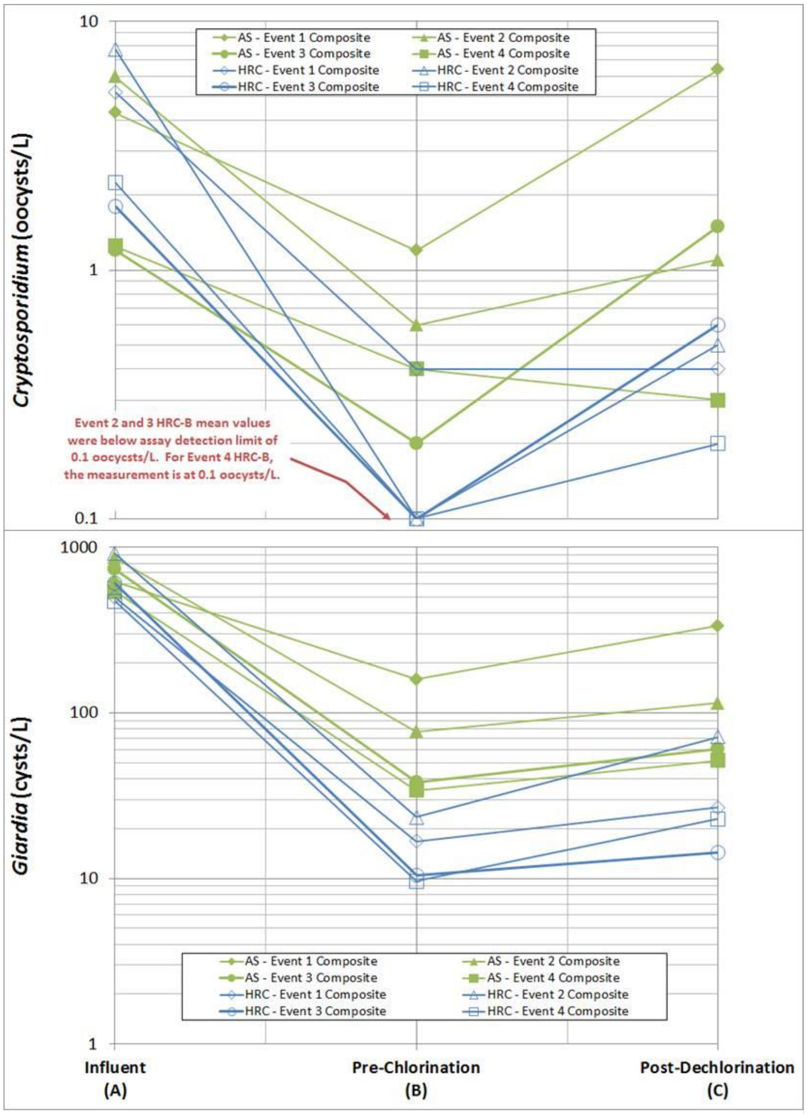

Figure 4. These charts show the *Cryptosporidium* and *Giardia* measured in each train at points (A) Influent, (B) Pre-Chlorination and (C) Post-Dechlorination.