Optimization of Filtration for Cyst Removal [Project #703]

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BACKGROUND
The primary objective of this project was to assess design and operational criteria used in the optimization of various treatment processes, especially filtration, to remove Cryptosporidium and Giardia. An additional objective was to investigate the relationship between particle removal and cyst and oocyst removal.

APPROACH
This study was conducted jointly by Montgomery Watson Americas, Inc. (MW) and the City of Portland, Oregon Bureau of Water Works (Portland). Pilot studies were conducted at the Contra Costa Water District (Contra Costa) in Concord, California; the City of Seattle, Washington, Water Department (Seattle); the Tualatin Valley Water District (Tualatin) in Beaverton, Oregon; and the City of Azusa, California, Azusa Valley Water Company (Azusa). In each of the four pilot studies, treatment variables were studied for their impacts on removal of seeded Cryptosporidium parvum oocysts, Giardia muris cysts, turbidity and particles. The Cryptosporidium and Giardia database generated in this study included 105 filter effluent data points for each organism.

RESULTS
Answers to the following practical questions about removal of Cryptosporidium, Giardia, turbidity and particles are based on the findings of this study.

Does a process train optimized for turbidity and particle removal also effectively remove cysts and oocysts? In general, when treatment conditions were optimized for turbidity and particle removal, very effective removal of both Cryptosporidium and Giardia was observed. Cryptosporidium removal ranged from 2.7 to 5.9 logs and Giardia removal ranged from 3.4 to 5.1 logs during stable filter operation in all four pilot studies.

Is Cryptosporidium removal similar to Giardia removal? In general, Cryptosporidium and Giardia were removed to the same extent. The median removal of 105 data points for each organism was approximately 4.2 logs.

If the Enhanced Surface Water Treatment Rule requires up to 6.0 logs of Cryptosporidium or Giardia inactivation-removal, is it realistic to expect 5.0 logs of removal by filtration (assuming 1.0 log of inactivation is achieved by disinfection)? Results of this study show that 5.0 logs of both Cryptosporidium and Giardia removal can be achieved with treatment conditions optimized for turbidity and particle removal.

Is turbidity removal an indicator of Cryptosporidium and Giardia removal? Turbidity removal did not correlate well with removal of either Cryptosporidium or Giardia. Turbidity was removed to a much lesser extent than was either organism. However, under the conditions tested, meeting a filter effluent turbidity goal of 0.1 ntu was indicative of treatment performance producing the most effective cyst and oocyst removal. A small difference in filter effluent turbidity (from 0.1 or less to between 0.1 and 0.3 ntu) produced a large difference (up to 1.0 log) in cyst and oocyst removal.
Is particle removal a surrogate for Cryptosporidium and Giardia removal? Removal of particles in size ranges of 1-2, 2-5, 5-15 and 1-25 mm did not correlate well with removal of either Cryptosporidium or Giardia. Further, a one-to-one relationship between particle removal and Cryptosporidium or Giardia removal was not observed, with particle removal consistently lower than organism removal. Use of particle removal as a surrogate for cyst (and oocyst) removal, as is presently recommended in the SWTR Guidance Manual (USEPA 1989), can therefore considerably underestimate cyst and oocyst removal under some conditions, such as the relatively high organism concentrations and relatively low turbidity and particle concentrations occurring in this study.

Is filtration effective for Cryptosporidium and Giardia removal during filter maturation? In general, removal of Cryptosporidium was 0.4 to 0.9 logs lower during filter maturation than during stable filter operation. Giardia removal was generally 0.4 to 0.5 logs lower during maturation.

What kind of process train produces the most effective removal of Cryptosporidium and Giardia? The three pilot plants which included sedimentation in the process train (conventional treatment with rapid mix, flocculation, sedimentation and filtration) produced more effective removal of Cryptosporidium and Giardia compared to an in-line filtration process train (rapid mix followed by filtration). However, the removal of both organisms through sedimentation was highly variable (ranging from virtually no removal up to approximately 4.0 to 5.0 logs), so the differences in removal between conventional treatment and in-line filtration could not be attributed solely to the fact that sedimentation was included in the process train.

What is the impact of chemical pretreatment on Cryptosporidium and Giardia removal? Chemical pretreatment was the single most important factor influencing Cryptosporidium and Giardia removal. Without chemical pretreatment with either metal ion coagulant or metal ion coagulant plus cationic coagulant aid polymer, the filters did not act as an effective barrier against the organisms.

What is the impact of filtration rate, filter media design and use of filter aid polymer on Cryptosporidium and Giardia removal? Using chemical pretreatment optimized for turbidity and particle removal, and the deep-bed filter media designs employed in the four pilot studies, filtration rate, filter media design and use of filter aid polymer were not found to impact cyst and oocyst removal.