Optimizing Filtration and Disinfection Systems with a Risk-Based Approach

This report shows treatment facilities managers how to evaluate their systems using particle guidelines as well as a step-by-step optimization process, so they can consider alternative configurations for their filtration and disinfection systems. This information will help wastewater facility operators consistently meet effluent standards for indicator organisms and be assured minimal risk from pathogens for downstream designated uses. The findings have practical process control applications.

This report presents a unique approach for ensuring adequate disinfection of microorganisms occluded in particles.

The research focused on optimizing filtration and chlorine disinfection systems to reduce the concentration of viable occluded microorganisms in wastewater effluents to acceptable levels. The optimization process was successfully applied to wastewater samples collected from seven facilities, each with different treatment trains. Particle guidelines and the optimization approach utilized existing regulatory framework for indicator organisms. Preliminary results suggest that intra-particle chlorine concentrations that are sufficient to inactivate indicator organisms may not be adequate to sufficiently reduce concentrations of occluded pathogens.

Evaluating Filtration and Disinfection Systems

The benefit of using the optimization protocols developed in this study is that facility managers can identify treatment system conditions (particle counts and chlorine dose) that yield acceptable results for the reduction of occluded target microorganisms in their effluents. Figure 1 summarizes the combinations of particle counts (for particles with diameters larger than 11 µm) and initial chlorine concentrations that resulted in total coliform counts of 2 MPN/100 mL. The chlorine contact time is 90-minutes to obtain the results. The guideline of 2 MPN/100 mL was selected because it is consistent with existing regulatory requirements, and it represents the detection limit for the total coliform assay.

Figure 1 demonstrates trends between operating conditions (e.g., ammonia nitrogen concentration) and the relationship between particles and disinfection system performance. With information on chlorine dose and particle counts, facility managers can plot their facility's data and make inferences about the effects that changes in the particle counts would have on downstream chlorine disinfection systems.

Implementing Optimization Protocols for Reduction of Occluded Target Microorganisms in Filtration and Disinfection Systems at Seven Facilities

The sequence of tasks in optimization includes collection of laboratory data, calibration of a computer model, collection of model output in simulations, concurrent development of particle guidelines, and identification of treatment conditions that result in acceptable reduction of occluded microorganisms. The researchers implemented optimization protocols at seven facilities. Five of the plants utilize a conventional activated sludge treatment strategy, one facility uses oxidation ditches, and one facility uses a pure-oxygen activated sludge treatment system. Particle size data (PSD) for the facilities revealed large concentrations of particles in secondary effluent samples with the highest total particle count of approximately 160,000 particles. The optimization protocols help managers of treatment

BENEFITS:

- Shows managers how to evaluate their systems using particle guidelines and the step-by-step optimization process.
- Helps managers evaluate results obtained for facilities with similar treatment trains and process control parameters.
- Develops particle guidelines for wastewater effluents based on existing regulatory framework for indicator organisms.
- Outlines a method for extending the concept of particle guidelines and optimization protocols to a pathogen basis.

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facilities draw the relationship between particles and the impact of performance on downstream disinfection systems.

Applying Optimization Protocols Reduces Microorganisms in Effluent Particles

This report presents a unique approach for ensuring adequate disinfection of microorganisms occluded in particles. To ensure pathogens' absence prior to use in water reuse project or discharge into sensitive waterbodies, facilities should directly monitor wastewater effluents. However, it is not easy to monitor pathogens. Using the radial pore diffusion model makes it possible to estimate the effects of varying particle counts and initial chlorine concentrations. It is possible to run simulations and estimate the survival of microorganisms potentially present in particles with model-calibrated site-specific data. The benefit of this research is that treatment facilities managers can make informed decisions regarding filtration and disinfection systems and adequately reduce the concentration of microorganisms in effluent particles.

Extending the Current Approach to Pathogens

The optimization protocols developed in this study were for inactivation of total coliform bacteria in disinfection studies frequently used in regulatory policies. The team used inactivation rate coefficients from the literature to estimate the inactivation of occluded pathogens. A disadvantage of using published inactivation rate coefficients was that the rates were not reflective of the water matrices in this research. Additionally, disinfection data were for lab strains of pathogens suspended in saline solutions, and rarely considered disinfection with combined chlorine. This study did not achieve a reduction of potentially occluded pathogens for most of the treatment scenarios considered. This highlights the importance of considering pathogens potentially present in particles, and of conducting site-specific analyses.

Future Direction for Optimization Protocols

The optimization protocols are beneficial to managers of treatment systems. Future study should repeat the protocols at a single facility to better define the range of filtration and disinfection system characteristics, including characterization of diurnal and seasonal trends and responses to plant upsets. In addition, the reliability of the optimization protocols would be higher by verifying some underlying assumptions, including the values of F and P, and assuming that occluded microorganisms have the same inactivation characteristics as dispersed microorganisms. Ultimately, the health risks related to particles in treated effluents need investigation to establish treatment goals that are protective of public health.

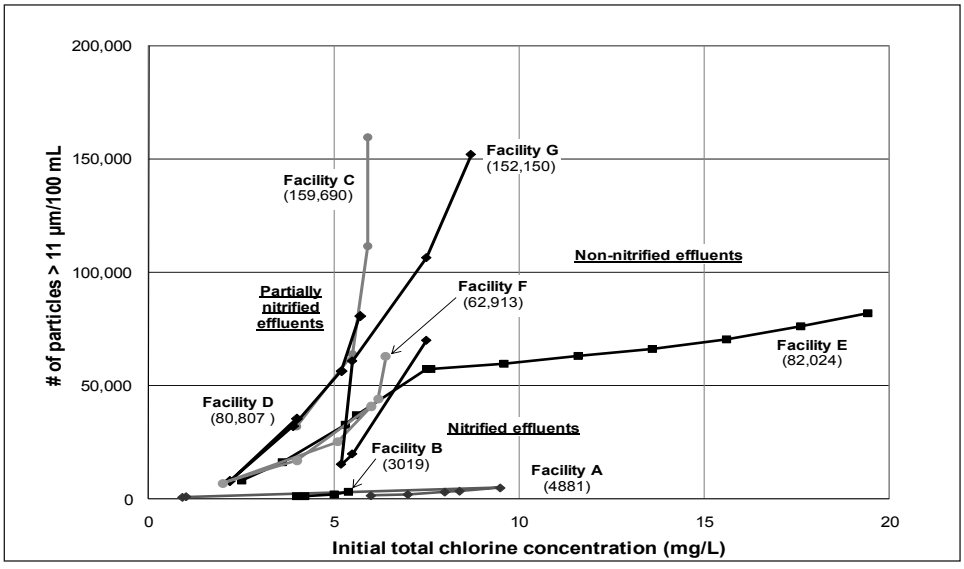

Figure 1. Combinations of Particle and Initial Total Chlorine Concentrations that Resulted in Occluded Total Coliform Concentrations of 2 MPN/100 mL, as Predicted Using Model Output (Original Particle Counts Per 100 mL for Each Facility Are Shown in Parentheses).

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