Indirect methods based on stochastical modelling for peracetic acid decay estimation in wastewater

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Introduction

Optimal control of wastewater disinfection, aimed at ensuring system reliability to minimize microbial risk, is essential in case of wastewater reuse. When peracetic acid (PAA) is used as disinfectant, natural loss of reactant occurs, with dependence on the wastewater matrix characteristics [1,2]. An accurate description of PAA decay in a specific wastewater matrix is usually carried out by laboratory experiments. In the present work, two indirect methods based on stochastical modelling for PAA decay estimation are explored, as effective, simple and fast alternatives to direct characterization. Both methods are based on monitoring data collected from the disinfection reactor. The final goal is to provide proper tools for real-time control.

Materials and methods

Two different methods to estimate PAA decay are developed using a pilot-scale disinfection reactor fed with secondary effluent in a WWTP (500,000 PE) located in the area of Milan (Italy), whose disinfection section is used for full-scale validation.

The first method is designed for the real-time estimation of PAA decay kinetics. The disinfection contactor is an open-chicane reactor, equipped with a probe for residual disinfectant measurement. A particle filter (PF) [3] has been developed, which continuously updates the PAA decay kinetic parameters estimation relying on the measurements of PAA residual concentration. Moreover, the *a-posteriori* probability density function of the estimates is computed, according to a Bayesian approach.

The second method aims at estimating PAA decay from bacterial counts in the disinfected effluent. The tool relies on the Integrated Disinfection Design Framework (IDDF) [4] as estimator of disinfection performance, given a hydrodynamic model of the contactor and a dose-response relation for bacteria inactivation. Through the IDDF model, the backward operation of PAA decay estimation is performed as a function of the outlet bacteria concentration and operating conditions of the process. The uncertainty of the estimator is accounted by a Monte Carlo approach.

Results and discussion

Firstly, the validation of the PF as a real-time estimator of PAA decay kinetic parameters has shown positive results. As reported in Figure 1a, the PF can follow the parameter trend accurately, also providing time-varying confidence bounds of the estimation. In detail, the *a-posteriori* probability distribution function of decay rate is provided at each time. Secondly, bacterial counts data resulted as a promising indirect way to estimate PAA decay during disinfection contact time. The IDDF model has been operated backward and an example result is reported in Figure 1b. The average lost PAA dose over the disinfection contact time has been estimated and, via Monte Carlo approach, the uncertainty coming from the assumed dose-response curve and variability related to operating conditions has been effectively propagated.

(a) (b)

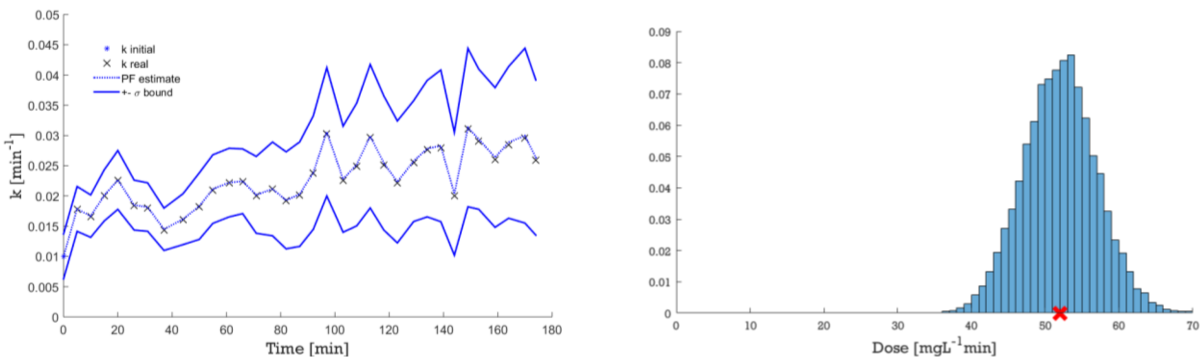

Figure 1 Time trend of PAA decay rate (k) and PF estimation (a).
Example of loss of PAA dose estimation (52 mgL^{-1}min) resulting from an observed 2.5 log reduction (b).

Conclusions

Two effective, simple and fast tools for indirect estimation of PAA decay have been proposed as support to PAA disinfection control. These innovative methods allow the exploitation of both real-time monitoring information from installed sensors and existing databases about bacteria inactivation on wastewater effluent. The presented efforts move towards a better integration of available data into the disinfection process control in the view of facing the current challenges for wastewater reuse.

References

[1] Domìnguez Henao L., Delli Compagni R., Turolla A., Antonelli M., Influence of inorganic and organico compounds on the decay of peracetic acid in wastewater disinfection, Chemical Engineering Journal 337 (2018) 133-142.

[2] Domìnguez Henao L., Cascio M., Turolla A., Antonelli M., Effect of suspended solids on peracetic acid decay and bacterial inactivation kinetics: Experimental assessment and definiition of predictive models. Science of the Total Environment 643 (2018) 936-954.

[3] Baraldi P., Cadini F., Mangili F., Zio E., Model-based and data-driven prognostics under different available information, Probabilistic Engineering Mechanics 32 (2013) 66–79.

[4] Bellamy W.D., Finch G.R., Haas C.N., Integrated disinfection design framework, AWWA Research Foundation and American Water Works Ass., 1998.