Integrated use of real-time sensors and process modelling to optimize wastewater disinfection by peracetic acid

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Introduction

Disinfection plays a key role in complying with microbiological quality standards in case of wastewater reuse. Among chemical disinfectants, peracetic acid (PAA) is a valid alternative to the commonly-used chlorine, thanks to its high spectrum of biocidal activity, the absence of halogenated disinfection by-product (DBPs) and the easy retrofitting of existing structures [1]. Anyway, it is affected by strong decay during the disinfection contact time which significantly depends on water quality [2]. The presence of suspended solids (SS) has proved to influence PAA disinfection in different ways: (i) enhancing PAA decay rate and (ii) promoting protection mechanism to bacteria [3]. The quantification of SS and microbiological enumeration by laboratory procedures requires many hours, consequently the development of real-time monitoring sensors is spreading in wastewater treatment plant (WWTP).

In the present research, a modelling framework for describing involved phenomena (PAA decay, bacterial inactivation) and accounting for system uncertainty by stochastic tools is developed and adapted to process real-time water quality monitoring data. The final goal is to assess the efficacy of recently developed sensors to evaluate the effect of SS on PAA decay and, consequently, on the overall performance of PAA on *E. coli* inactivation, in the view of real-time control.

Materials and methods

The study is focused on a pilot-scale disinfection reactor which was fed with the secondary effluent of a WWTP (500,000 PE) located in the area of Milan (Italy). Before the inlet section of the reactor, wastewater was analysed by a particle counter instrument (Grundfos Bacmon) which classifies particles as bacteria or abiotic particles [4]. The hydrodynamic behaviour of the disinfection reactor was characterized by tracer tests and the disinfection process was modelled using the Integrated Disinfection Design Framework [5]. The model for the influence of SS on PAA decay rate and the dose-response model were derived from a previous work [3]. A Monte Carlo approach was used to propagate uncertainty related to parameters.

Results and discussion

The elements of the modelling framework were developed using experimental data and an existing WWTP database. The particle count data showed a weak but statistically significant correlation with SS content and *E. coli* enumeration. Moreover, it is worth noticing that peaks of particles occurred in combination with high flow rate (Figure 1a), mostly due to rainy events. The hydrodynamic behaviour was successfully modelled as a combination of conceptual reactor models (plug-flow and continuously-stirred tanks), and residence time distribution was obtained at the outlet section. The elaboration of particle count data within the modelling tool allowed to calculate the optimal PAA dosage necessary to achieve the required bacterial inactivation as a function of the actual water quality characteristics. The main modelling result was the probability of non-compliance (PONC) from the estimation of the probability density function (PDF) of the model output, as shown in Figure 1b.

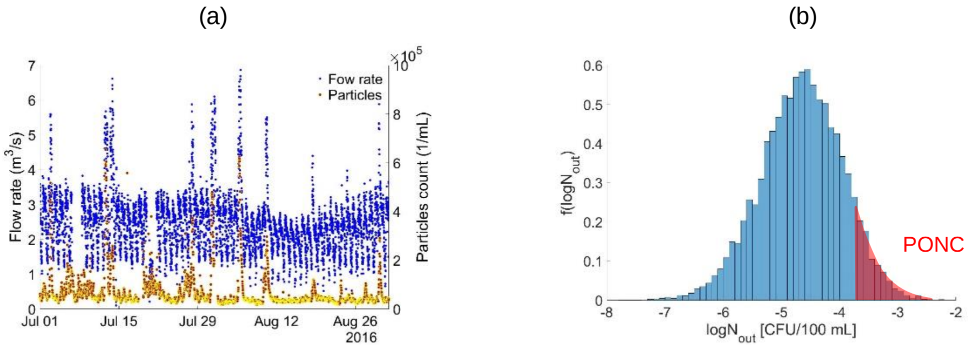

Figure 1 (a) Particle count and wastewater flow rate at the inlet section of the reactor; (b) example of PDF of bacterial inactivation resulting from Monte Carlo simulations and estimated PONC.

Conclusions

A modelling framework based on real-time monitoring data was developed to control disinfectant dosage to assure bacterial inactivation required to wastewater reuse even in case of unexpected changes in water quality, possibly related to rainy events. In particular, the effective integration of innovative on-line sensors was evidenced.

References

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