International Journal of Hygiene and Environmental Health 219 (2016) 700–708

Contents lists available at ScienceDirect

International Journal of Hygiene and Environmental Health

journal homepage: www.elsevier.com/locate/ijheh

Reducing pathogens in combined sewer overflows using performic acid

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ARTICLE INFO

Article history:
Received 6 December 2015
Received in revised form 14 April 2016
Accepted 17 April 2016

Keywords:
Viruses
Bacteria
Parasites
Disinfection
Combined sewer overflows
Performic acid

ABSTRACT

Combined sewer overflows contribute significantly to pathogen loads in surface water. Some chemical disinfectants such as chlorine have proved to reduce the levels of microorganisms even in complex matrices such as wastewater in combined sewer systems; however, some of them release toxic by-products into water bodies and increase costs of plant maintenance and repair. In this study, we determined if performic acid (PFA) disinfection units can be operated at decentralized treatment facilities and reduce bacteria, viruses, and protozoan parasites in combined sewer overflows (CSOs). The PFA dosing unit at the inflow of a CSO storage tank dosed a fixed flow volume into the inflowing stormwater and, thus, concentrations varied between approximately 12–24 mg l^{-1}.

The results showed a reduction of most hygienically relevant bacteria with mean removal efficiencies of 1.8 $\log_{10}$ for *Aeromonas* spp. and 3.1 $\log_{10}$ for *E. coli*. For viruses, however, reduction was only observed for somatic coliphages with 2.7 $\log_{10}$. In this setting, PFA does not seem to be suitable to remove e.g. protozoan parasites such as *Giardia lamblia.* In terms of operation, dosing the substance is uncritical in decentralized facilities, but the PFA needs too much time to react with pathogens after being dosed into the overflow of CSO storage tanks and before dilution with surface water in most facilities.

1. Introduction

Combined sewer overflows (CSOs) contribute significantly to pathogen loads in surface water (Tondera et al., 2016). Due to the stochastic and variable nature of CSOs, it is difficult to disinfect them since treatment units are used irregularly, but have to operate at full capacity within a very short period of time.

Some disinfectants have proved to substantially reduce pathogens in CSOs in large scale application, such as chlorine (King County, 2011). However, chlorine needs special care when being handled and its reaction by-products can increase the toxicity of the treated wastewater, especially under high concentration of organic compounds (Watson et al., 2012), which is the case for CSO. For this reason, alternative disinfectants are needed. In addition, disinfection units should be easy to operate, especially in decentralized discharge facilities. Furthermore, besides eliminating as many pathogens as possible, the disinfectants should not increase the toxicity of the treated sewage.

Performic acid (PFA) could be a very useful alternative in order to reduce pathogens in wastewater since some evaluations postulated a very short response time (Ragazzo et al., 2013) and a high disinfection rate at relatively low doses (Maya et al., 2012).

Indeed, limited data are available about the required dose for raw wastewater as CSO, which has different chemical parameters than wastewater after biological treatment. Gehr et al. (2009) monitored wastewater that was only primarily treated with coagulating agents in order to remove suspended solids and phosphorus. The authors investigated the removal of different bacteria and coliphages with different concentrations of PFA for a month. For fecal coliforms, the inflow values were between 5×10^5 to 1.4×10^6 cfu $(100\,ml)^{-1}$, and the $\log_{10}$ reduction followed the added PFA concentration: 2–4 mg l^{-1} resulted in approximately 2–3 $\log_{10}$ and > 6 mg l^{-1} in 5–6 $\log_{10}$ (45 min contact time). For intestinal enterococci (I. E.), the authors achieved a reduction of 4–6 $\log_{10}$ with doses of 5–6 mg l^{-1} and 1–2 $\log_{10}$ for coliphages and *Clostridium* (90 min contact time; no inflow values provided).

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http://dx.doi.org/10.1016/j.ijheh.2016.04.009
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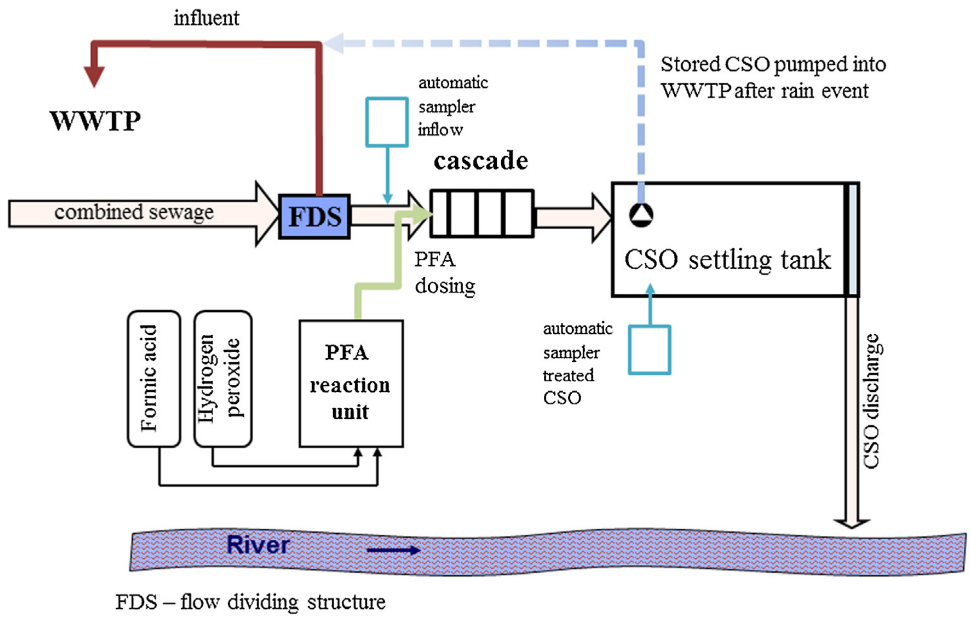

Fig. 1. Scheme of PFA experimental setup at CSO structure Velbert Hespertal.

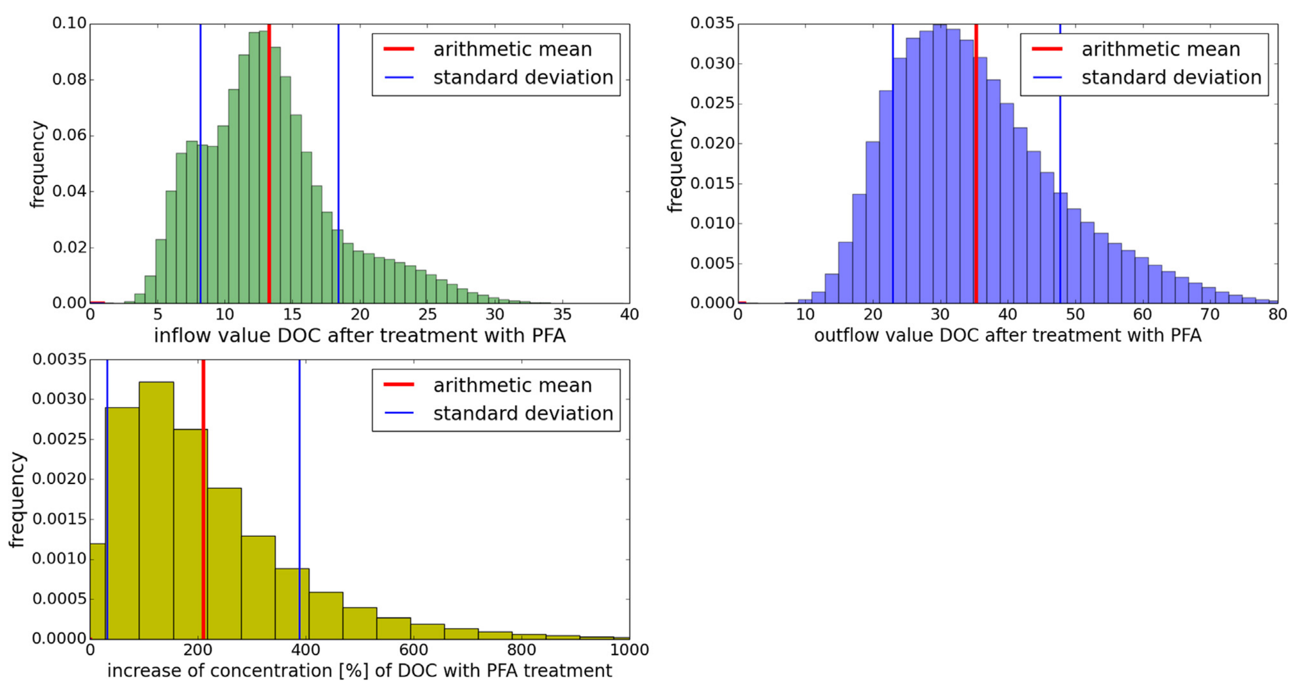

Fig. 2. Histograms of DOC before and after disinfection with mean value (bold vertical line) and standard deviation.

In laboratory scale experiments, Chhetri et al. (2014) reached a 4 $\log_{10}$ removal for *Enterococcus* in artificial CSO within 10 min and an added PFA concentration of 4 mg l^{-1}, compared to the same removal with peracetic acid (PAA) at 5 mg l^{-1} after 360 min. Chhetri et al. (2015) examined PFA on CSO events and showed that 8 mg l^{-1} min^{-1} reduced approximately 2.0 $\log_{10}$ of *Escherichia coli* (*E. coli*) and 1.3 $\log_{10}$ of I.E (contact time of 20 min.)

The quick reaction is also an advantage in comparison to PAA (Chhetri et al., 2014). Another advantage of using PFA is that the reaction chamber providing PFA seems to be tolerant to long standstills, which can occur during dry seasons without CSOs. Recent studies could also not prove that disinfection by-products were generated other than formic acid and water or that eco-toxicity or toxicity increased significantly compared to untreated CSO (Ragazzo et al., 2013; Chhetri et al., 2014). Chhetri et al. (2014) observed a degradation of PFA with a dose of 4 mg l^{-1} up to 62 % within the first minute depending on the proportion of raw wastewater in artificial CSO. After 120 min, the PFA was degraded completely.

A few studies have examined how effective PFA treats CSO in pilot and large scale applications (Chhetri et al., 2014, 2015). These studies have focused on indicator bacteria such as *E. coli* and I.E., – which are crucial indicator parameters for fecal matter and found in the EU Bathing Water Directive (EU, 2006). This directive defines under which circumstances a surface water body can be legally used as bathing water and how the water quality has to be monitored. Surface waters classified as bathing water have to at least fulfil a “sufficient” quality in order to keep the status as