Chemical aspects of peracetic acid based wastewater disinfection

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ABSTRACT

Peracetic acid (PAA) has been studied for wastewater disinfection applications for some 30 years and has been shown to be an effective disinfectant against many indicator microbes, including bacteria, viruses, and protozoa. One of the key advantages compared to, e.g., chlorine is the lack of harmful disinfection by-products. In this paper a pilot-scale study of PAA-based disinfection is presented. Indicator microbes (*E. coli*, total coliforms and coliphage viruses) as well as chemical parameters (pH, oxidation-reduction potential (ORP), chemical and biochemical oxygen demand (COD and BOD), and residual PAA and hydrogen peroxide) were studied. The main aim of this investigation was to study how these selected chemical parameters change during PAA treatment. Based on the results, disinfection was efficient at C·t values of 15 to 30 (mg·min)/ℓ which equals to a PAA dose of 1.5 to 2 mg/ℓ and a contact time of 10 to 15 min. In this concentration area changes in pH, COD and BOD were negligible. However, hydrogen peroxide residues may interfere with COD measurements and apparent COD can be higher than the calculated theoretical oxygen demand (ThOD). Additionally PAA or hydrogen peroxide residues interfere with the BOD test resulting in BOD values that are too low. Residual PAA and ORP were found to correlate with remaining amounts of bacteria.

Keywords: tertiary wastewater disinfection, peracetic acid, total coliform, *E. coli*, coliphages

INTRODUCTION

Wastewater treatment has traditionally focused on the removal of solids, organic material and nutrients (phosphorus and more recently nitrogen). Additionally, microbes in wastewater are typically removed up to about 98% in a conventional treatment process without disinfection (Tchobanoglous et al., 2004). Remaining pathogens are often thought to diminish via dilution in natural waters or to be inactivated by stress factors such as pH, temperature, salinity, nutrient availability, and oxidative stress (Rozen and Belkin, 2001). However, this is not always sufficient if there are activities taking place which involve the receiving water body, such as bathing, fishing or fish farming for example. Globally, microbiological quality of wastewater is becoming ever more important due to the water scarcity in many areas and therefore the need to recycle or reuse treated wastewater is now considerably higher than before.

There are many alternative techniques for wastewater disinfection that can be used individually or in combination: chlorine compounds (gas and hypochlorite), chlorine dioxide, ultraviolet (UV) radiation, ozone, and peracetic acid (PAA). Chlorine is still globally the most common disinfectant due to its low cost, however the awareness of harmful by-products and the formation of chlorination-resistant bacteria strains causes wastewater plants to consider other options. Recently performic acid (PFA) has also been proposed as a wastewater disinfectant but additional research is necessary as there are currently no published results about, e.g., by-product formation and toxicity effects (Gehr et al., 2009).

The role of PAA in wastewater disinfection has been extensively studied since the early 1980s and PAA has also been used as a disinfectant for many years in the food, beverage, and paper industries (Orth, 1998; Rasimus et al., 2011). PAA is commercially available as a stabilised equilibrium mixture containing PAA (typically 5 to 15% w/w), hydrogen peroxide, acetic acid, and water (Eq. (1)). PAA is considered to be the main active component in the solution (Baldry, 1983; Baldry and French, 1989; Fraser et al., 1985; Kitis, 2004; Lubello et al., 2002).

$$CH_3COOOH\ (aq) + H_2O\ (l) \leftrightarrow CH_3COOH\ (aq) + H_2O_2\ (aq) \quad (1)$$

The disinfection efficiency of PAA in wastewater applications has been demonstrated numerous times in the literature (Antonelli et al., 2006; Baldry, 1983; Baldry and French, 1989; Baldry et al., 1991; Baldry et al., 1995; Briancesco et al., 2005; Collivignarelli et al., 2000; Dell'Erba et al., 2004; Gehr et al., 2003; Kitis, 2004; Koivunen and Heinonen-Tanski, 2005a; Koivunen and Heinonen-Tanski, 2005b; Lefevre et al., 1992; Liberti and Notarnicola, 1999; Liberti et al., 1999; Salgot et al., 2002; Veschetti et al., 2003; Zanetti et al., 2007). As a result, PAA is gaining acceptance as a disinfectant, especially in the United Kingdom and Italy (Falsanisi et al., 2006). Examples of full-scale installations include Milan Nosedo wastewater treatment plant (WWTP) in Italy and Mikkeli Kenkävero WWTP in Finland.

A recent study by Azzellino et al. (2011) showed that PAA disinfection is more dependent on dosage than on contact time. This indicates that the traditional C·t (dose amount x contact time) concept may need a weighting coefficient for the *t* term. Additionally, PAA seems to possess faster inactivation kinetics for *E. coli* compared to total coliform bacteria (TCB), which was also confirmed by Mezzanotte et al. (2007). These findings are important in terms of selecting a representative indicator microbe and interpreting disinfection test results.

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