Performic acid for advanced wastewater disinfection

T. Karpova, P. Pekonen, R. Gramstad, U. Öjstedt, S. Laborda,
H. Heinonen-Tanski, A. Chávez and B. Jiménez

ABSTRACT

The disinfection efficiency of performic acid (PFA) against various microbial contaminants has been studied in municipal secondary effluent. The study demonstrated that PFA provides rapid, efficient and safe disinfection, degrading both bacteria and viruses even at low doses. The resistance order starting from the most resistant microorganism is as follows: MS2-coliphages > DNA-coliphages > Enterococci and *Escherichia coli.* PFA is also efficient in the elimination of *Salmonella* spp., *Clostrium perfringens* spores and *Giardia* cysts. The results showed that a PFA dose as low as 0.5–1 mg l^{-1} with contact time of 10 min was efficient in achieving and maintaining for 72 h the disinfection level required for unrestricted agricultural water reuse ($\leq$3 log units for faecal coliforms). However, the optimal dose will depend on the quality of wastewater. Regarding the formation of by-products during disinfection with PFA, very low amounts of hydrogen peroxide and organic per-acids were observed; active oxygen was not detected. The amounts of adsorbable organically bound halogens (AOX) compounds formed were significantly lower compared to the amounts generated during chlorine disinfection. This chlorine-free solution enables compliance with microbiological criteria for various water reuse applications and is already on the market for advanced disinfection.

Key words | human health, hydroxyl radical, microbiological criteria, oxidation, per-acids, water reuse

T. Karpova (corresponding author)
P. Pekonen
Kemira Oyj,
Espoo R&D Center, Luoteisrinne 2,
P.O. Box 44, 02271 Espoo,
Finland
E-mail: *tatjana.karpova@kemira.com*

R. Gramstad
U. Öjstedt
Kemira Kemi AB, Koppargatan 20,
P.O. Box 902, 25109 Helsingborg,
Sweden

S. Laborda
Kemira Germany Sales GmbH,
Unterschweinstiege 2–14, 60459 Frankfurt/Main,
Germany

H. Heinonen-Tanski
Department of Environmental Science,
University of Eastern Finland,
P.O. Box 1627, 70211 Kuopio,
Finland

A. Chávez
B. Jiménez
Instituto de Ingeniería, Universidad Nacional Autónoma de México,
Apdo Postal 70472; Ciudad Universitaria; 04510 Coyocan DF,
Mexico

INTRODUCTION

Today, many places in the world face water scarcity, which drives people to search for alternative water sources. The issue of water shortage will continue to escalate due to the constant increase in water demand. Moreover, the deterioration of traditional raw water resources due to pollution raises environmental and health concerns. This is especially evident in areas with a single raw water source. The emphasis is on preserving the highest quality water sources for potable water production by using an alternative source, such as reclaimed water, for non-potable applications. Thus, water reuse mainly for non-potable purposes is becoming increasingly widespread.

In order to prevent potential adverse effects, used water needs to be treated to a certain quality. Among other pollutants, microbial contaminants pose a high risk. Even though conventional municipal wastewater treatment methods can reduce 90–99% of pathogens, the effluent still contains enteric microorganisms that can cause harm to human health (Koivunen *et al.* 2003). Certain EU countries have already introduced legal demands for disinfection of the entire effluent flow. The determining factor for employment of entire effluent disinfection is compliance with water quality standards and guidelines defined in the EU Water Framework Directive (2000/60/EC), EU Bathing Waters Directive (2006/7/EC) and Urban Wastewater Treatment Council Directive (91/271/EEC).

Disinfection is required if the water is being reused in some applications. Strict microbiological water quality standards are set for various water reuse applications such as agricultural and landscape irrigation, urban and industrial uses, augmentation of surface water bodies as well as groundwater recharge. The minimum pathogen removal requirements are application specific.

Chlorination is quite efficient in removing many enteric bacteria, but it is less effective against viruses, bacterial spores and protozoan cysts (Tyrrell *et al.* 1995; Veschetti

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