

Effect of pretreatment by permanganate/chlorine on algae fouling control for ultrafiltration (UF) membrane system

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Received 18 December 2006; accepted 3 January 2007

Abstract

The use of ultrafiltration (UF) is receiving more attention for drinking water treatment, but its fouling remains a problem. Reservoir water was selected as raw water during pilot study. Worldwide drinking water reservoirs may contain algae, which pose a threat to drinking water treatment. UF membrane has been recognized that it can remove algae for its nominal pore sizes. The algal cells cumulate on membrane surface, and the secretion released by them would cause transmembrane pressure increases or flux decreases. Also, conventional backwashing could not satisfy with the need of flux recovery. Frequent chemical cleaning may shorten the membrane unit's service life. The best available technology for UF membrane system during algae bloom should be inactivating algae and removing them before they are fed into UF membrane. The objective of this study was to investigate the effect of pretreatment by permanganate/chlorine on UF membrane operation for controlling algae fouling. It was found that combined use of permanganate and chlorine could reduce the rate of UF membrane fouling. Permanganate and chlorine could be in synergistic action in inactivating algal cell. The intermediate of permanganate, hydrous manganese dioxide (MnO_2) could adsorb on algal cells depending on its strong specific surface area. In addition to permeate water quality, specific flux (at constant TMP) and TMP (at constant flux) of UF membrane also demonstrated that pretreatment could improve UF membrane system.

Keywords: Ultrafiltration (UF); Pretreatment; Permanganate; Chlorine; Algae fouling

1. Introduction

Recently, ultrafiltration (UF) technology has been in progress as an alternative to conventional

drinking water treatment [1]. UF has been known effective for the removal of turbidity, particulates and pathogens to meet more stringent regulations [2]. However, UF membrane fouling problems have become an impediment to wide application [3]. Especially for the algae-rich feed water, algae

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Presented at the conference on Desalination and the Environment. Sponsored by the European Desalination Society and Center for Research and Technology Hellas (CERTH), Sani Resort, Halkidiki, Greece, April 22–25, 2007.

secrete an extracellular, mucilaginous slime material, which could cement particulates on the membrane surface and increase the resistance to filtration [4].

Several studies have developed potential pretreatment options for UF membrane fouling control [5–9]. Pretreatment has greatly expanded the use of UF membrane system beyond turbidity and pathogen removal. Preoxidation was often adopted in chemical pretreatment, and the preoxidants were investigated widely. Numerous literatures have reported that preoxidants such as ozone, chlorine, or permanganate can improve algae removal by coagulation and filtration process. These preoxidants served as both algacide and flocculant aid [10–13].

Traditionally, prechlorination has been found to be an effective method to aid the coagulation of waters with a high organic content or algae blooms. Sukenik et al. found that chlorine had distinct effect on algal cell surface architecture, which resulted in the release of cellular organic compounds [14]. However, the use of chlorine is subjected to cause the formation of trihalomethanes (THMs) and haloacetic acids (HAAs), which are harmful by-products and this limits its use in many countries [15]. Plummer et al. reported that ozone caused the release of extracellular organic matter (EOM), which made coagulation easier and caused the increase of THM precursors [12,13]. Petrushevski et al. showed that permanganate inactivated motile micro-organisms and induced in situ production of natural, algae-derived coagulant aid [11]. Chen et al. studied the mechanism of potassium permanganate on algae removal. They reported that permanganate could promote the aggregation of algal cells [10]. However, for the disadvantages of inactivation efficiencies and color, permanganate pretreatment needs to be enhanced. The pretreatment step improved or deteriorated the coagulation and disinfection process by changing the nature of the water.

Synergistic effects of the chemicals have received more and more attention recently [16–19].

Combined use of permanganate and chlorine has been proved to be in synergistic action and the application of permanganate/chlorine controlled the production of THMs [20]. For reservoir water, permanganate and chlorine have been applied and the synergistic effects were also testified. It was indicated that combined use of permanganate and chlorine in pretreatment ensured the microbial and chemical safety for water treatment [21]. Based on the synergistic effect, permanganate and chlorine have been applied in combination to inactivate algal cells and remove them by enhancing coagulation [22].

In this study, therefore, the effect of reservoir water pretreatment by permanganate/chlorine on algae fouling control for UF was investigated.

2. Experimental

2.1. Raw water characteristics

Algae-rich reservoir water was selected in this study. A summary of the raw water quality is shown in Table 1.

2.2. Jar tests

To optimize the dosing of coagulants and preoxidants, jar tests were conducted with a six-unit stirrer apparatus. Pretreatment by permanganate/chlorine followed by aluminum chloride (alum) coagulation-sedimentation was investigated. Different amounts of permanganate or/and chlorine were mixed at 200 rpm with water samples in each beaker for 1 min. Then all of the water

Table 1
Feed water characteristics

Turbidity (NTU)	4.62–8.91
pH	7.92–8.00
COD _{Mn} (mg/L)	2.2–2.8
Algae count ($\times 10^4$ cell/L)	690–1230
Temperature (°C)	25.1–28.5

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