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Effect of Coagulation on Submerged Ultrafiltration Membrane

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Abstract

The possibility of minimizing the coagulation dosage in ultrafiltration (UF) drinking water treatment was assessed using a pilot-scale membrane operation in relation to membrane fouling. A 1,000 m^3/d submerged UF system was used with a constant low dosage of coagulant. The results of investigating the normalized fouling rate during runtime indicated that membrane fouling was fairly controlled in the presence of a low concentration of PACl, even though a slight rise in the transmembrane pressure occurred.

Keywords: Coagulation, Drinking water treatment, Membrane fouling, Ultrafiltration

1. Introduction

Membranes have been widely adopted in drinking water treatment plants to provide reliable water quality by removing a variety of pathogenic microorganisms and particulates [1]. However, a major drawback of membrane technology is the membrane fouling caused by the colloids and dissolved substances in natural water [2, 3]. In order to sustain comparable membrane properties, proper pretreatment is necessary. Pretreatment generally plays a critical role in surface water treatment because of the wide fluctuation in water quality. Among the various pretreatment methods available, such as media filters [4], activated carbon [5, 6] and adsorbents [7, 8], coagulation has been commonly used as a cost-effective pretreatment method to remove organic matter and colloids [9-11]. Coagulants are easily hydrolyzed in water to neutralize the surface charge of negatively charged particles and form aggregates of a removable size by allowing particles to bind due to

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attractive forces. The amount of coagulant to use in drinking water treatment can be determined based on the turbidity of the source water. However, in general, these are used excessively to the upper limit of the suitable level when considering the additional reactions with co-existing substances in the source water. Despite the benefits of coagulation, it has several problems. It is difficult to determine the coagulant dosage with rapid water quality changes in a short period of time such as during flooding, and results from Gabelich et al. [12] indicated that an overdose of coagulants will result in a positively charged state, leading to a great decrease in the coagulation efficiency and causing the remaining coagulant to foul the membrane. Many studies have been performed to find the optimal dosage of coagulants to reduce membrane fouling. However, membrane systems for water treatment have been operated under apparently different conditions with higher allowances for the coagulation dosage rather than the desired level. Therefore, it is necessary to investigate the effect of low coagulation on membrane fouling, which may contribute to the design of a membrane system.

In this study, the possibility of minimizing the coagulation dosage in ultrafiltration (UF) drinking water treatment was assessed using a pilot-scale membrane operation in relation to membrane fouling.

2. Materials and methods

2.1. Source water

The source water used in this research was Han River surface water, which was obtained from the KW water treatment plant in Hanam, South Korea. Raw water for the current study was pumped to the pilot-scale UF treatment system before the intake basin. Table 1 lists the characteristics of the source water. Although the water quality of the Han River changes seasonally, it typically contains relatively high turbidity and organic substances.

Table 1. Source water quality

Parameter	Water quality
pH	7.7±0.3
Turbidity (NTU)	10.5±46.8
COD (mg/L)	4.5±0.8
TOC (mg/L)	1.5±0.7
Total coliform (counts per100 mL)	115±78

2.2. Pilot-scale UF treatment system

The 1,000 m^3/d large-scale UF pilot system was composed of auto-screening, pre-coagulation, and submerged membrane filtration using a second-stage UF membrane. All of the membrane modules were polyvinylidene fluoride (PVDF) hollow fiber membranes (SB module, Cheil industries. Inc., South Korea). The first stage of the system consisted of two trains and was operated in a dead-end mode with a constant flux of 35.4 LMH. In the second stage, cross-flow filtration was used to produce a filtrate flow of 14.3 LMH. The membrane modules were designed with an outside-in flow configuration, and the fibers had an inside diameter of approximately 0.8 mm. In addition, the surface area and average molecular-weight cutoff (MWCO) provided by the manufacturer were 42 m^2 and 300 kDa, respectively. In the first stage, the operation cycle included permeation for 100 min and a combination of backwash and air scouring for 5 min. At the end of each operation cycle, the membrane tank was fully drained of the air bubbles associated with scouring. In