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Performance evaluation of submerged membrane bioreactor for the removal of microalgae from the source water of a water treatment plant

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ABSTRACT

Freshwater algal blooms negatively impact the operations of water treatment plants when they are present in the source water. In the present study, an application of a low-cost submerged microfiltration membrane bioreactor for the removal of microalgae from a source water reservoir of a water treatment plant was evaluated. The experiments were conducted in different phases to systematically evaluate how different fouling control methods such as air scouring and water backwashing in combination with vibration technique can enhance the flux and removal efficiency of microalgae in a submerged flat sheet microfiltration membrane bioreactor. Combining backwashing with air scouring (Phase 3) positively enhanced the flux by reducing the TMP, but it did not improve the permeate quality in terms of microalgae and turbidity removal. The results of Phase 4 studies confirmed that vibration had a profound effect on microalgae removal compared to backwashing technique while reducing the TMP from 105 to 103 kPa. The average turbidity removal was increased from 76.75% to 82% when vibration is applied. Combining all fouling control methods such as air scouring, backwashing and vibration methods did not appear to be effective for the removal of microalgae and turbidity (Phase 5). In order to signify the energy input on membrane fouling control, flux in each phase was assessed with respect to total power input. In overall, air scouring at a rate of 7 L/min with 50 Hz of vibration appeared to be an optimum condition in controlling fouling without any frequent backwashing.

1. Introduction

The occurrences of algal bloom in reservoirs has posed a serious threat to conventional water treatment due to clogging of filter beds in water treatment plants, poor water quality in terms of taste, color, odor and formation of algal toxins and disinfection byproducts, [1]. Several techniques have been used for the removal of algae from surface water, including sedimentation, coagulation, ultrafiltration, air floatation, ultrasonic inactivation, copper sulfate inhibition and advanced oxidation [2]. Although all of these techniques appear to be effective in the removal of algae from water, most of these methods create secondary pollution issues such as formation of algae residues, sludge formation etc. except in the case of ultrafiltration. The use of ultrafiltration membranes has gained widespread attention for the separation of microalgae from surface water due to complete rejection of algal cells through size exclusion. However, pretreatment such as coagulation, adsorption or pre-oxidation techniques are still required to prevent membrane fouling during ultrafiltration [3]. In light of recent research directions toward algal-based technologies in wastewater treatment and biofuel production, there is considerable interest in using microfiltration membranes to harvest microalgae. Despite the interests in using membranes in algal systems, there has been some disagreement concerning energy consumption and controlling membrane fouling in real life applications of membranes [4,5]. In such applications, it is always critical to control the dynamic cake layer on membrane surface which is influenced by the buildup of foulants such as microalgae cells, cell detritus, inorganic colloidal particles, and dissolved organic matter [6–9].

Conventional fouling control methods could be categorized into physical, mechanical, and chemical cleaning based on the cleaning agents used [10,11]. It is commonly accepted that the best methods for preventing non-adhesive fouling are reduced permeate drag force, moderate flux rate, and increased shear force [12,13]. Several past researchers have attempted to study the foulant control by mechanical methods including air scouring, back-pulse, and ultrasound [14,15].

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