MICROFILTRATION HYBRID SYSTEMS IN WASTEWATER TREATMENT FOR REUSE

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CERTIFICATE OF AUTHORSHIP/ORIGINALITY

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signature of Candidate

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I dedicate this work to my parents

(Deyi Fu and Liren Guo)

&

Youhao Wu

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NOMENCLATURE

A_M	the surface area of the membrane (m^2)
b	adsorption affinity, a constant related to the heat of adsorption
C	concentration of the adsorbate in the solution (bulk phase concentration, mg/L)
C_b	the organic concentration in the bulk phase in the reactor (mg/L)
C_e	equilibrium concentration of the solute (mg/L)
Ce	effluent concentration
Ci	influent concentration
C_o	the organic concentration in the feeding tank (mg/L)
C_r	$Q\beta$ concentration in the bulk phase
C_r^∞	equilibrium concentration of $Q\beta$ in the bulk phase
Cs	the concentration of the external surface of PAC particles (mg/L)
D_e	the free liquid diffusivity of the solute
D_s	the surface diffusion coefficient (the rate of diffusion of the target compound along the surface of the carbon, m^2/s)
H	adsorption constant (Henry's Law)
k	the first order reaction coefficient
k_a	coefficient for adsorption onto PAC
k_m	coefficient for attachment to the membrane
k_d	coefficient for the bacterial decay, and
k_e	coefficient for inactivation due to the desorption of $Q\beta$ from PAC
K	constants characteristic of the system
K_f	the external mass transfer coefficient (m/s)
k_s	the solid mass transfer coefficient
M	the weight of PAC used (g)
MCC	the membrane correlation coefficient

n parameter in the Sips equation

$1/n$ constants characteristic of the system

q measured amount of organic matter adsorbed onto a unit amount of adsorbent (mg/g)

q^o maximum adsorbed phase concentration (mg/g)

q_e saturation amount of organic adsorbed (mg/g)

q_m amount of solute adsorbed per unit weight of adsorbent required for monolayer capacity (mg/g)

q_t the rate of change of surface concentration with time (t) at any radial distance (r) from the center of the activated carbon particle during adsorption (mg/g)

Q the flow rate (m^3/s)

R radius of carbon particle, L

T temperature

V the volume of the bulk solution in the reactor (m^3)

V_M the volume of membrane (m^3)

W PAC dose

$[(M/V)\cdot(dq/dt)]$ represents the adsorption of the organics onto PAC in suspension

$[(A_M/V_M)\cdot MCC\cdot C_b]$ describes the adsorption onto the PAC layer deposited onto membrane surface

Greek letters

ζ parameter $(=\Psi(1+K\Psi))$

ψ organic concentration spreading parameter

δ the thickness of the diffusional sublayer

ρ_p apparent density of the activated carbon (kg/m^3)

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ABSTRACT

Generally, the conventional wastewater treatment cannot remove all the effluent organic matter (EfOM) such as synthetic organic chemicals and natural organic matter etc. As a result, the biologically treated effluent from sewage treatment plant needs to undergo further advanced treatment processes. To obtain water of recyclable quality, initially physico-chemical processes such as flocculation, sedimentation, filtration and adsorption were normally used. However, with advanced technologies and ever increasing stringent water quality criteria, membrane processes are becoming more attractive in water reuse.

Among different membrane processes, although microfiltration (MF) can be operated economically, it alone cannot remove organic matter. If MF is combined with an enhanced flocculation or/and adsorption, it will be able to reduce superior level of organic contaminants. The aims of this study are: (i) improving the dissolved organic removal and reduce membrane fouling of two membrane hybrid systems (crossflow microfiltration (CFMF) and submerged membrane adsorption hybrid system (SMAHS)) using different pretreatment methods (flocculation, adsorption and flocculation-adsorption); (ii) investigating the critical flux of a laboratory-scale CFMF with and without different pretreatments.

The incorporation of powdered activated carbon (PAC) as pretreatment to CFMF resulted in high TOC removal efficiency (more than 80%) when the PAC-CFMF system was operated at a relatively high filtration flux of 250 $L/m^2.h$. The incorporation of flocculation and PAC as pretreatments to CFMF process resulted in a very high TOC removal efficiency (99.7%) and a stable filtration flux during 5-hour filter run (less than 12% flux decline), when the hybrid system was operated at a higher filtration flux (270 $L/m^2.h$).

Application of membrane processes requires lower investment and operating costs. One of the ways is to operate system at a constant filtration flux below the critical flux. With both flocculation and adsorption as pretreatment to CFMF, the critical flux of biologically treated effluent increased dramatically (5-7 times increase).

The preadsorption, PAC dose, aeration rate and filtration flux had effects both on organic matter removal efficiency and TMP development. The preadsorption of 1 hour prior to the membrane operation was important in mitigating the membrane fouling. The suitable aeration rate, filtration flux and initial PAC dosing were 16 L/min, < 24 $L/m^2.h$ and 5 g/L respectively for the wastewater used in this study. The long term SMAHS experiments conducted with regular PAC replacement indicated that the PAC replacement in PAC-MF reactor could stimulate both biological activity and adsorption, as well as optimize the operation of the hybrid system.