Characteristics of Submerged Membrane Hybrid System for Water and Wastewater Treatment

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(Seoul National University)

Effect of Coagulation Conditions on Membrane Filtration Characteristics in Coagulation-MF Process for Water Treatment

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Coagulation-MF Process for Water Treatment

Introduction

•상수원 수질 악화, 수질 기준 강화 ---> 기존 정수처리 공정의 한계 노출

•막분리 공정

처리효율의 안정성 확보, 처리시설의 자동화, 소형화 가능

막오염으로 인한 플럭스 감소 문제 대두

--> 물리,화학적 세척법 사용, 다양한 전처리와 결합

정밀여과(MF)

•높은 탁도, 미생물 제거율
•낮은 작동 압력

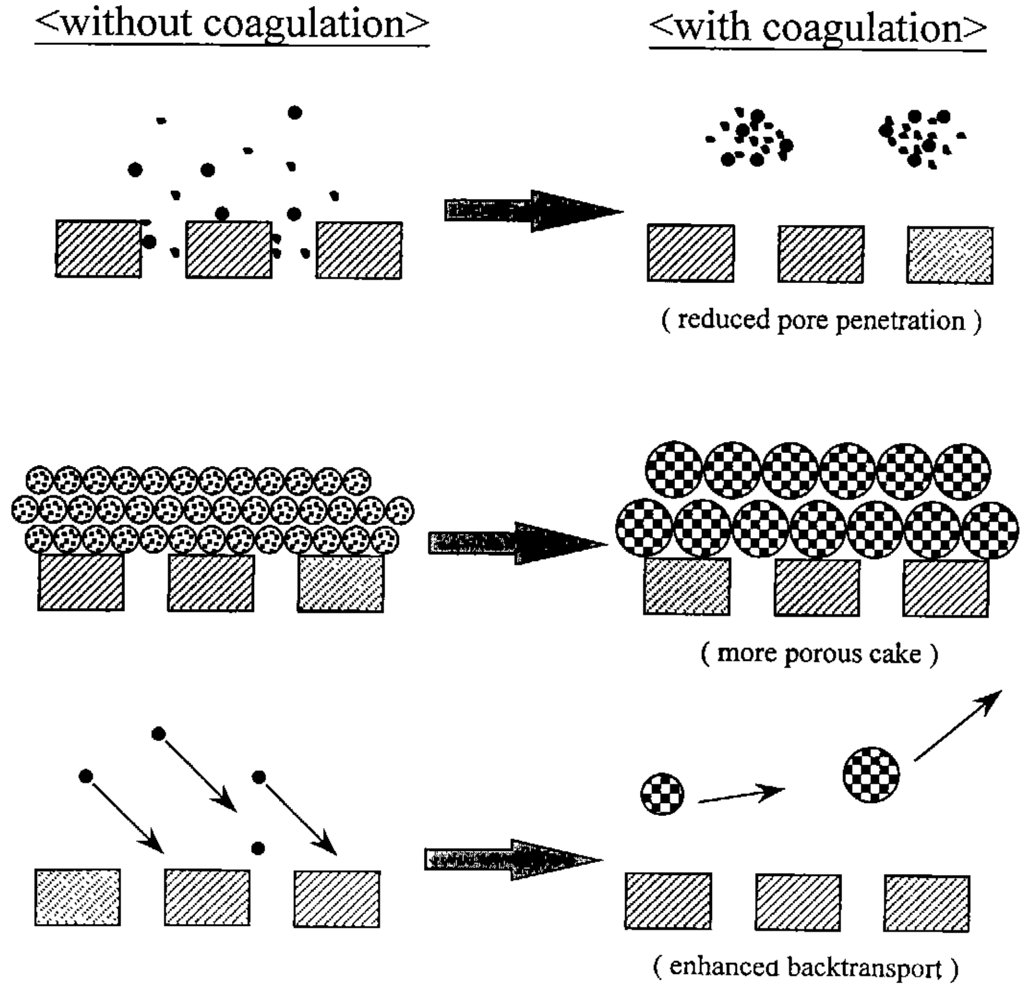
\+

응집(Coagulation)

•플럭스 증가
•유기물 제거율 증가

Possible mechanisms by which coagulation pretreatment may enhance flux

(Wiesner *et al.*, 1996)



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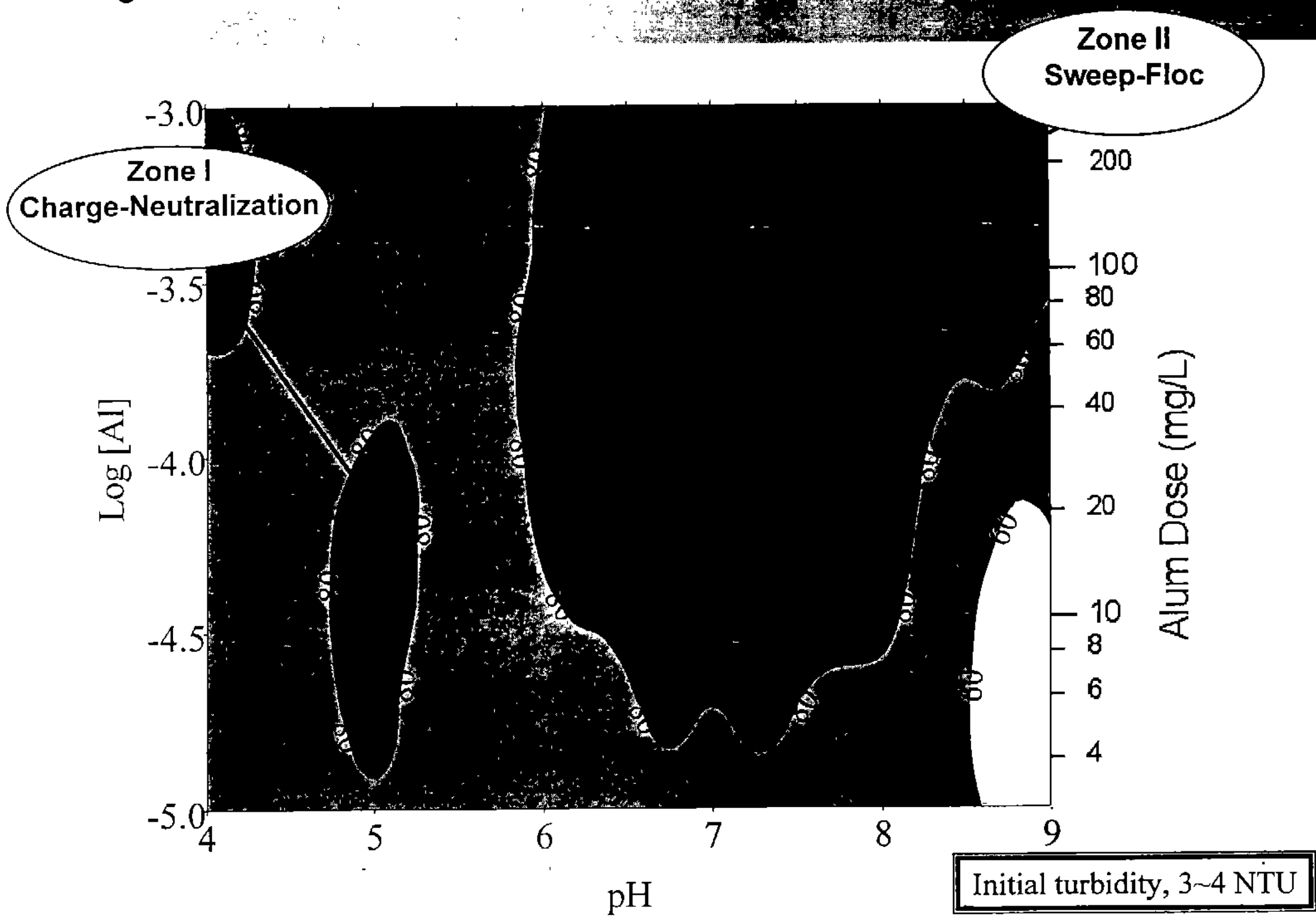
Percentage Removal of Turbidity as a fuction of Alum Dose and pH



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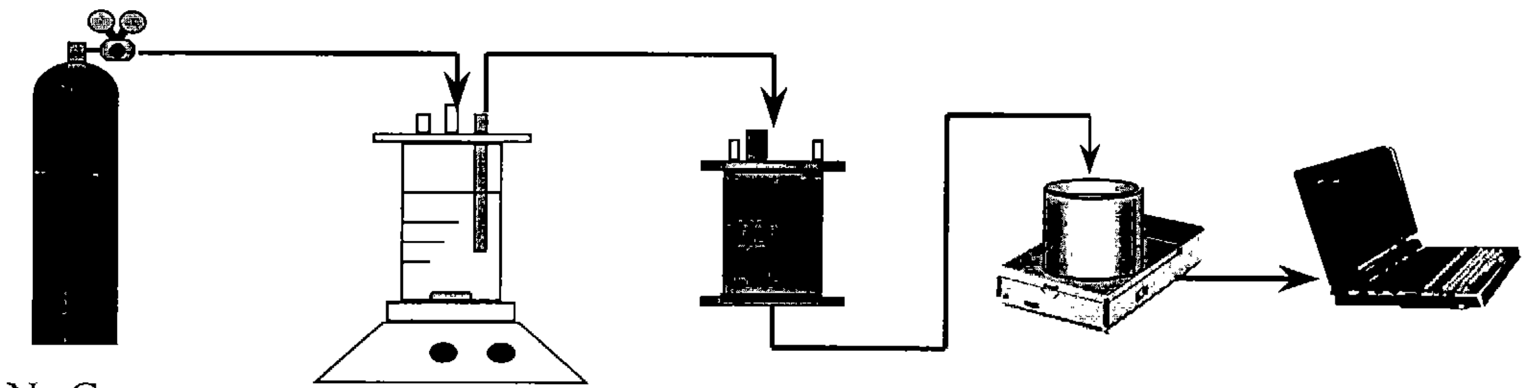
Experimental Set-up for a Batch Unstirred Cell to determine the Specific Cake Resistance

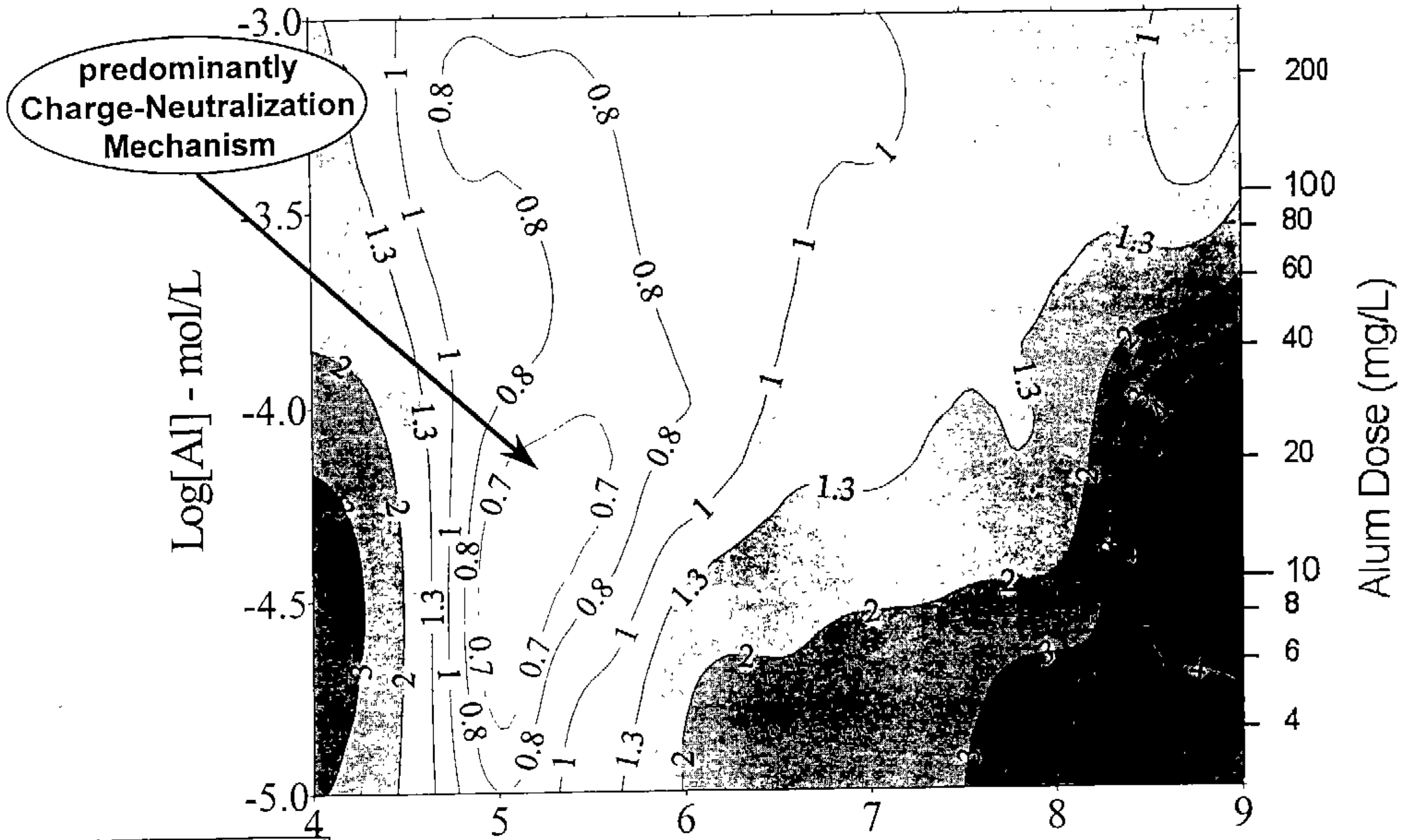


$$\frac{t}{V} = \frac{\mu R_{m}}{A_m \Delta P} + \frac{\alpha \mu C_b}{2 A_m^{2} \Delta P} V$$

from slope of t/V vs V Plot ⟶ Specific Cake Resistance, α

$$\alpha = \frac{180(1-\varepsilon)}{\varepsilon^3 \rho_c d_c^2}$$ (for spherical cake particle)

Relative Specific Cake Resistance ($\alpha_{Rel} = \alpha_{Coag} / \alpha_{Raw}$) through Unstirred Cell Microfiltration with Alum Coagulation



For Raw Water,
α_{Raw} =2.5 ~ 3 * 10^{12} m/kg

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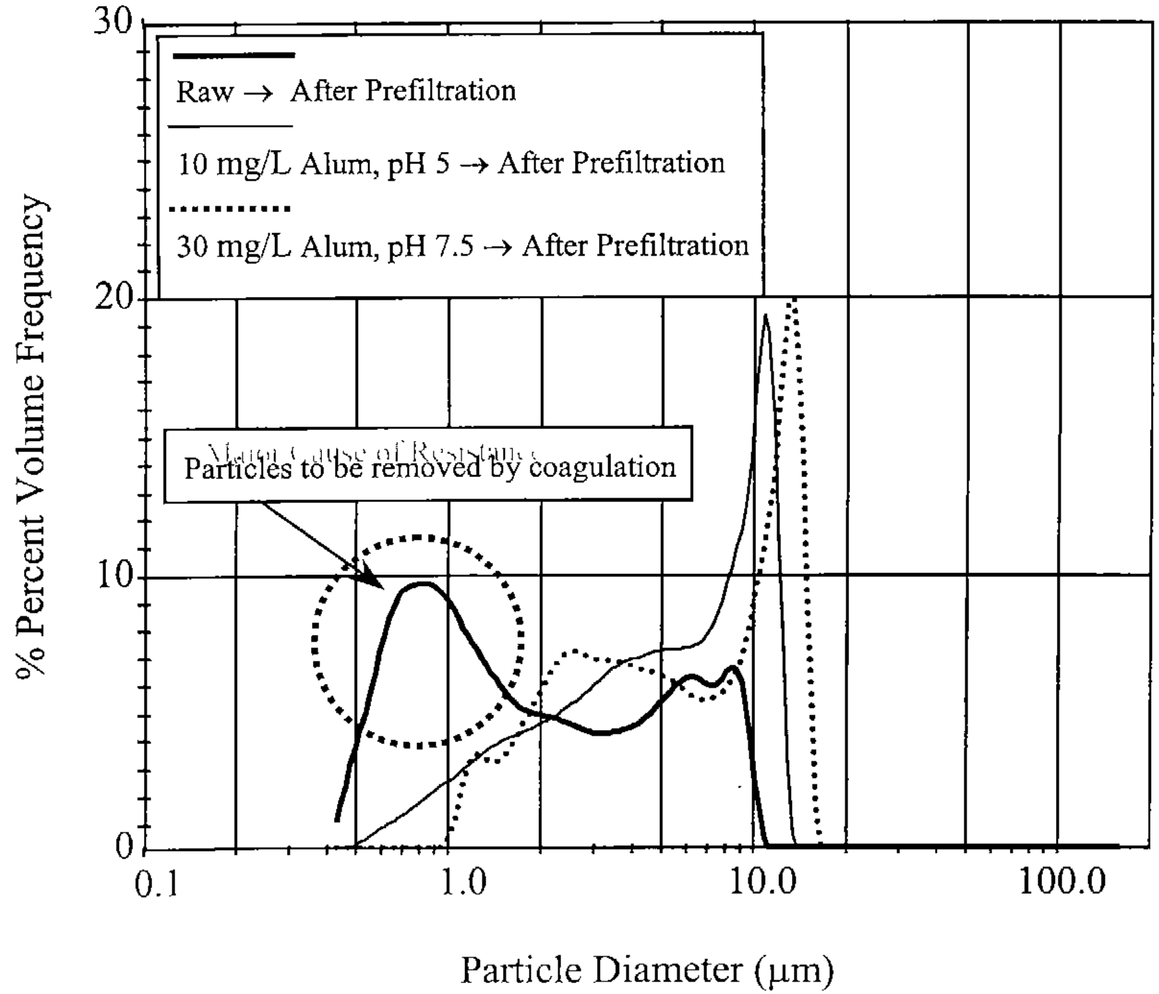
Particle size distribution of coagulated suspensions during microfiltration after prefiltration with 8 um filter



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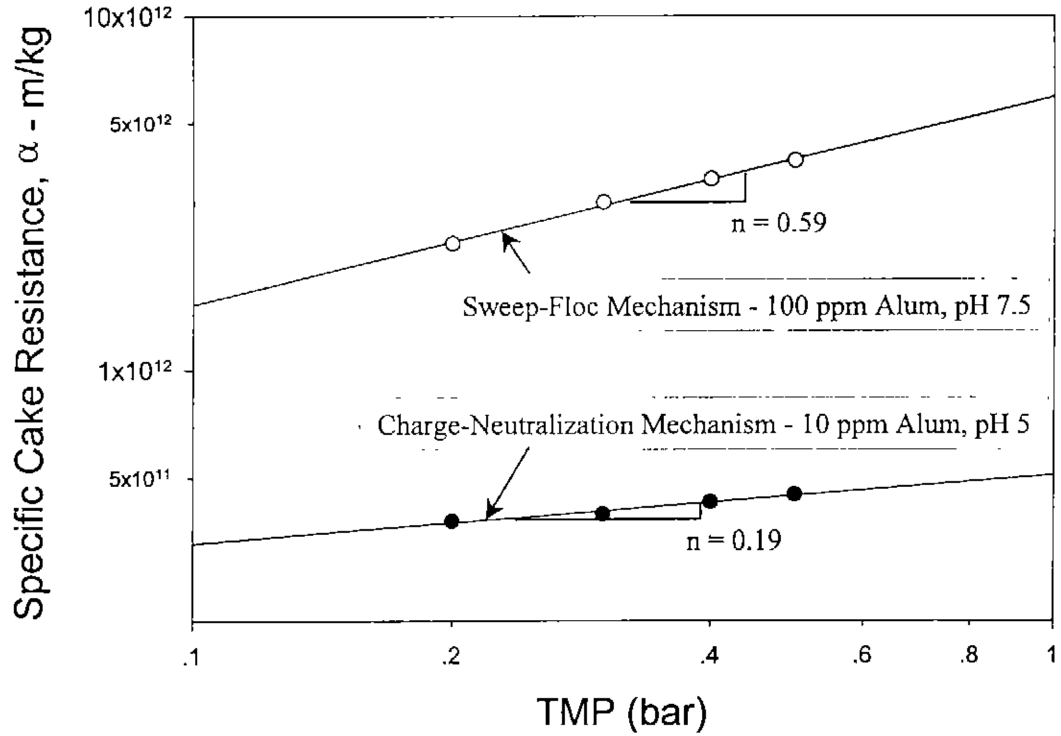
Variation of specific cake resistance with TMP at different coagulation conditions

Effect of transmembrane pressure on specific cake resistance

$$\alpha = \alpha_0 \, \Delta P^{\,n} \qquad (n : \text{compressibility index})$$



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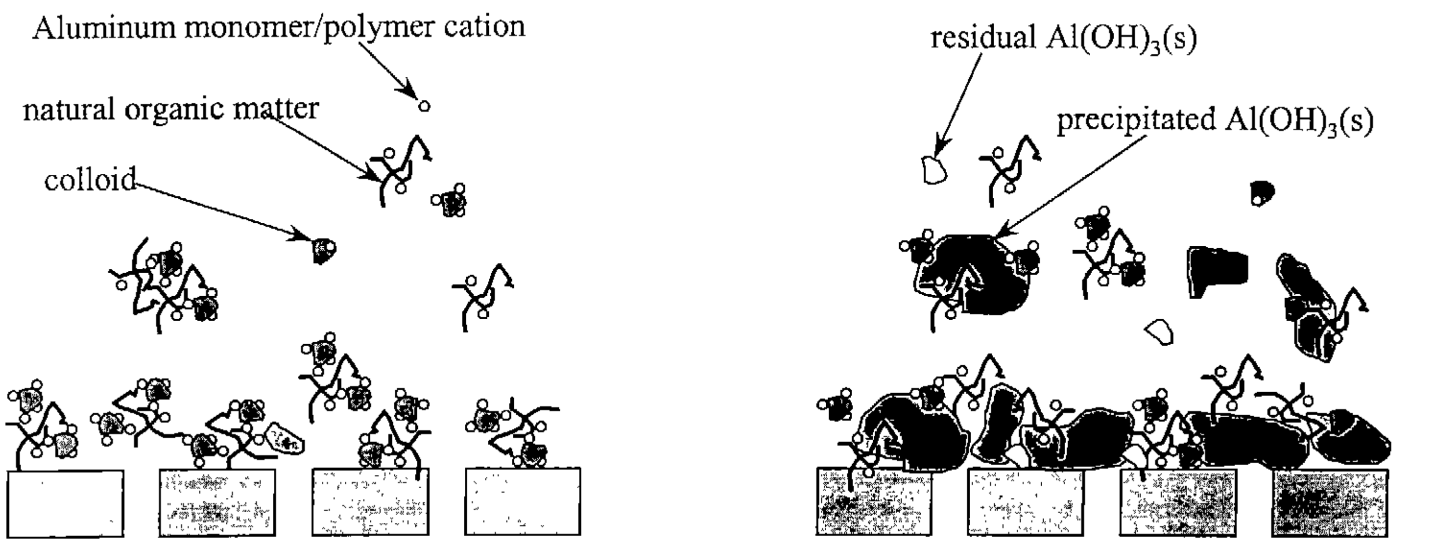
Comparison of two types of coagulated flocs formed at different coagulation conditions



(medium, rigid, less compressible flocs)

< Predominant Mechanism : *Charge-Neutralization* >

Lower α

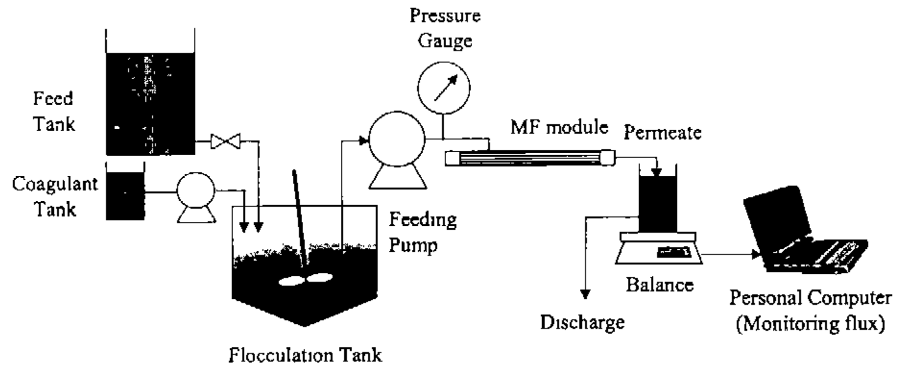
(large, compact, gelated, more compressible flocs)

< Predominant Mechanism : *Sweep-Floc* >

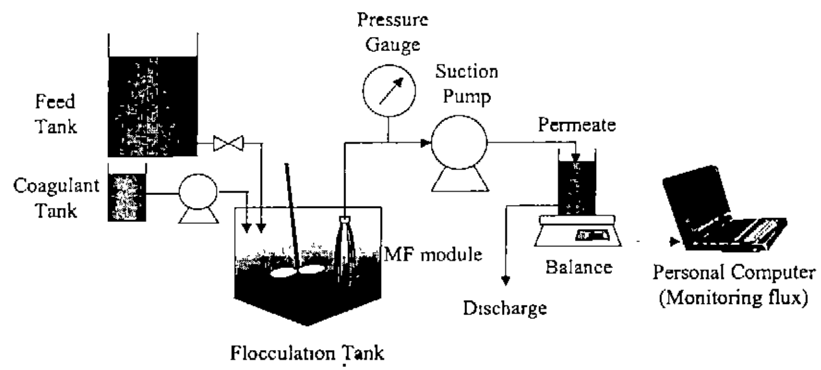
Higher α

Schematics of experimental set-up for coagulation-microfiltration hybrid processes

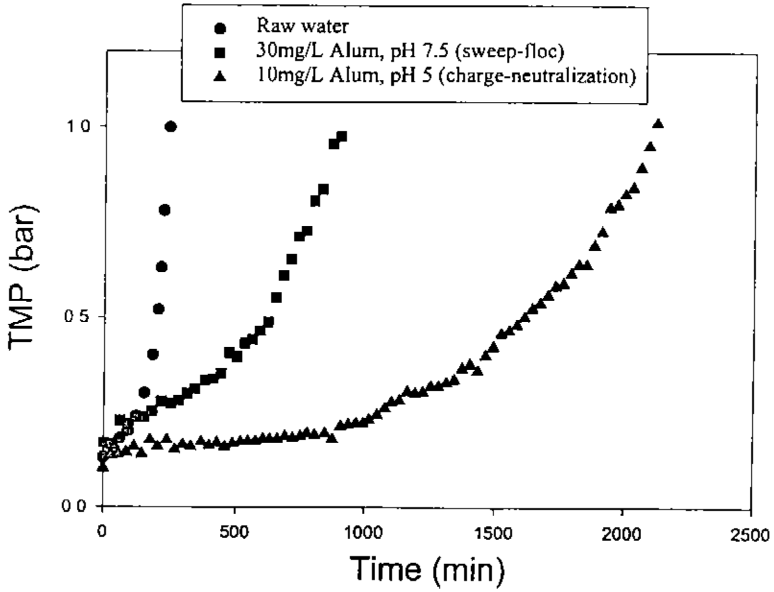
Dead-end MF
(External-pressure Type)



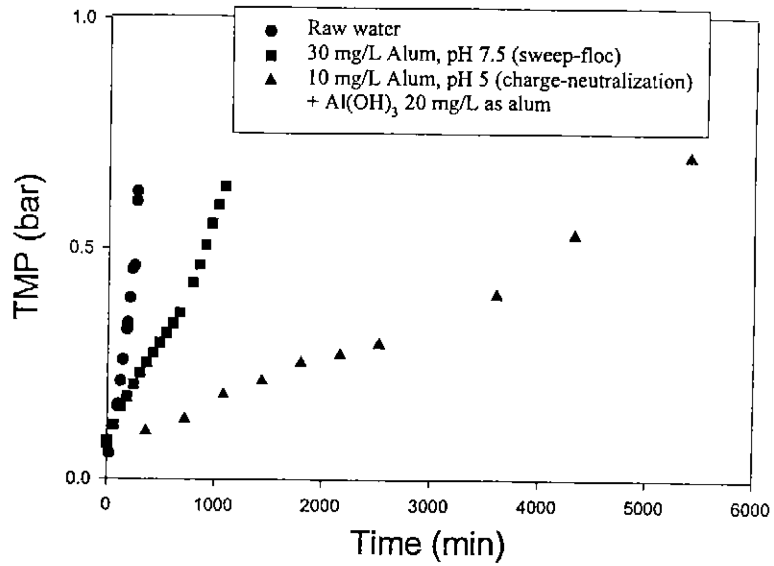
Dead-end MF
(Submerged Type)



Variations of TMP at constant flux during dead-end microfiltration



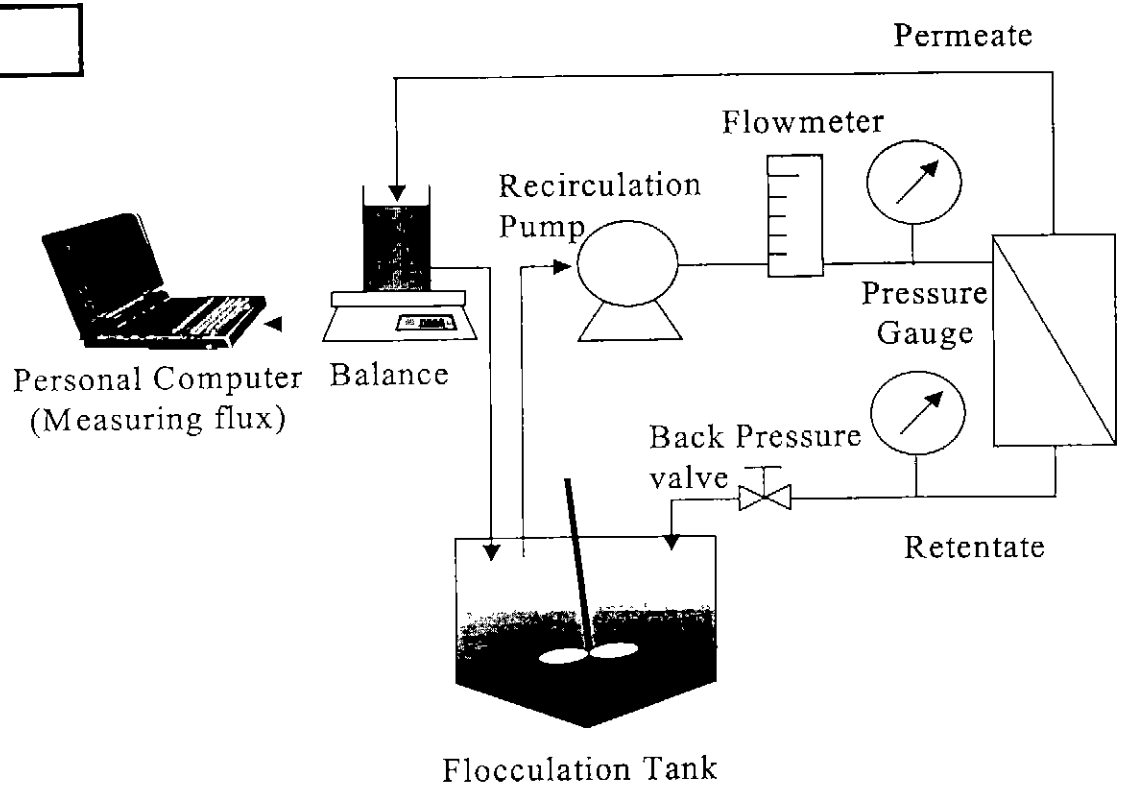
External Pressure Type



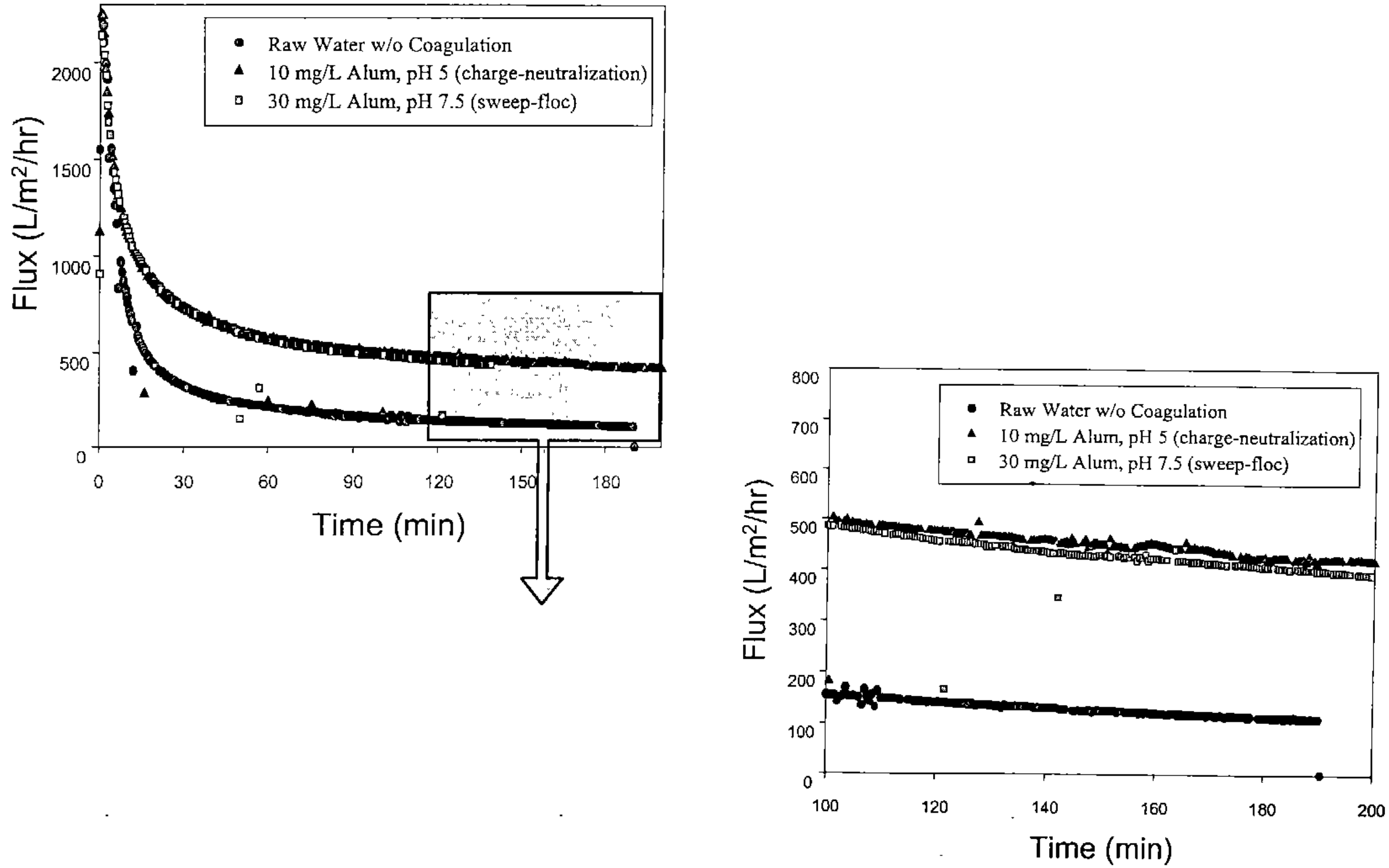
Submerged Type

Schematics of experimental set-up for coagulation-microfiltration hybrid processes

Crossflow MF



Flux variation at constant TMP during crossflow microfiltration of coagulated suspensions made at different coagulation conditions.



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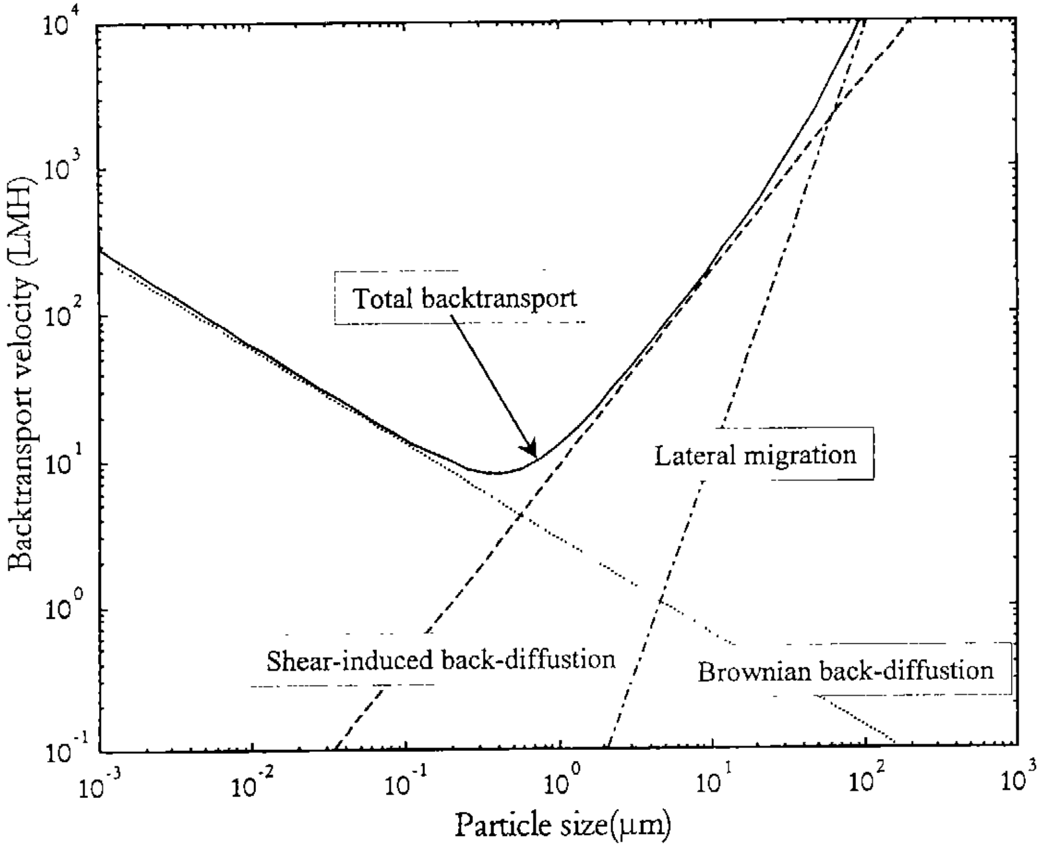
Backtransport velocity with particle size in crossflow filtration



1) Brownian backdiffusion

$$v_B = k_m \ln(\frac{C_w}{C_b})$$

2) Shear-induced backdiffusion

$$v_s = 0.078(\frac{r_p^4}{L})^{\frac{1}{3}} \gamma_w \ln(\frac{C_w}{C_b})$$

3) Lateral migration

$$v_l = 0.577\frac{u_m^2 r_p^3}{\nu h^2}$$

(temperature : 25°C, average tangential velocity : 0.22 m/s, channel height : 3 mm)

Effect of Alum and Zeolite Addition on the Performance of the Submerged Membrane Bioreactor

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기존 연구의 현황과 한계점

- 막오염 현상과 이로 인한 처리수 생산량 감소
  Modification of module configuration
  Operation mode : Continuous/Intermittent suction
  Regular washing : Air back washing, Jet aeration

  : 실용적인 측면에서만 접근, 막오염 현상 해석 미약

- 처리수 수질 향상
  Application of Single stage or
  A/O process : 양호한 유기물 제거 및 질산화/탈질
  : 부하의 변동, 온도의 변화에 따른 질산화 효율 감소
  : 미생물의 활성 또는 거동에 대한 연구 미흡
  : 생물학적 인 제거 효율 미약

Introduction

본 연구의 목적

- 막오염 현상에 대한 해석

  막오염 원인 물질, 막오염 감소 대책

- Alum 응집제와 Natural Zeolite의 도입

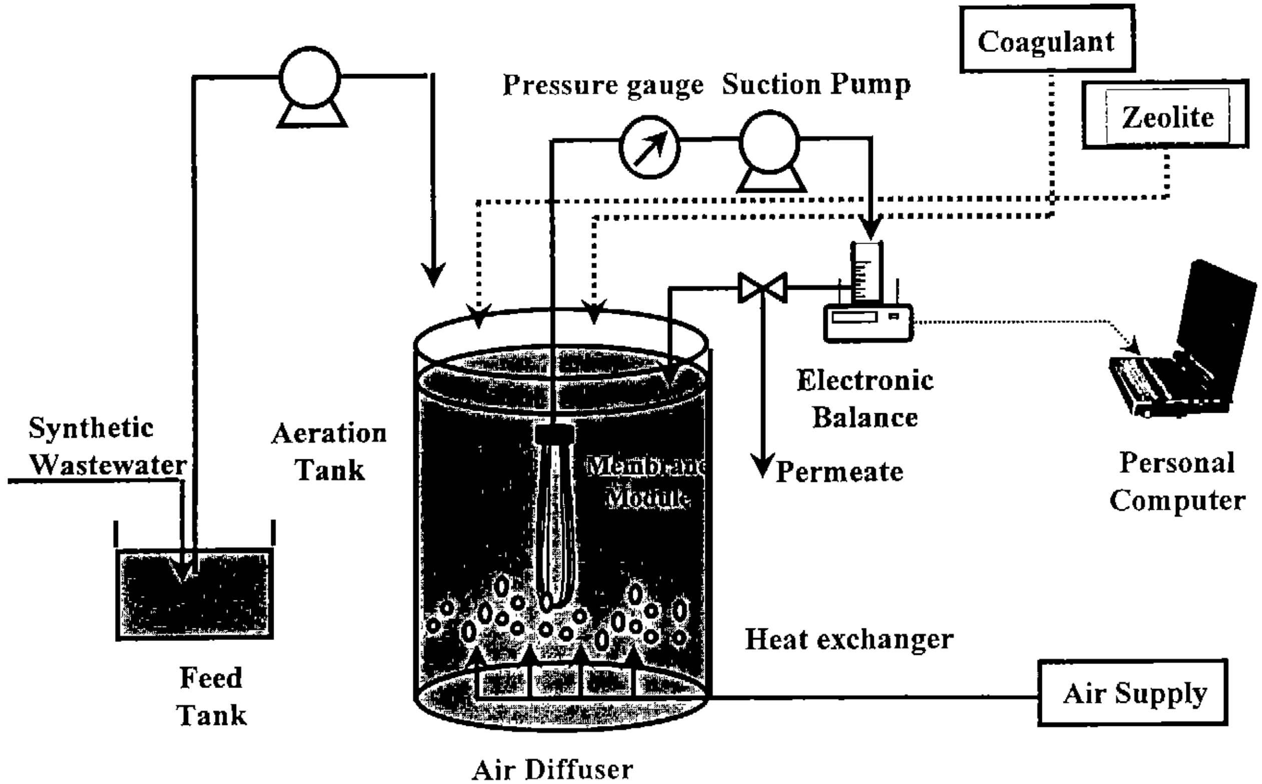
  막오염 감소 및 여과 성능의 향상, 원인분석

  Alum 투여로 인제거 향상

  Zeolite 투여로 질산화 향상 (미생물 활성과 관련)

  Alum 및 Zeolite 동시 투여로 질소 및 인의 동시제거

Schematics of submerged membrane bioreactor



장 치 도, 운 전 조 건

Aeration 역할 설명

분리막의 물리적 세정, 미생물에 산소공급

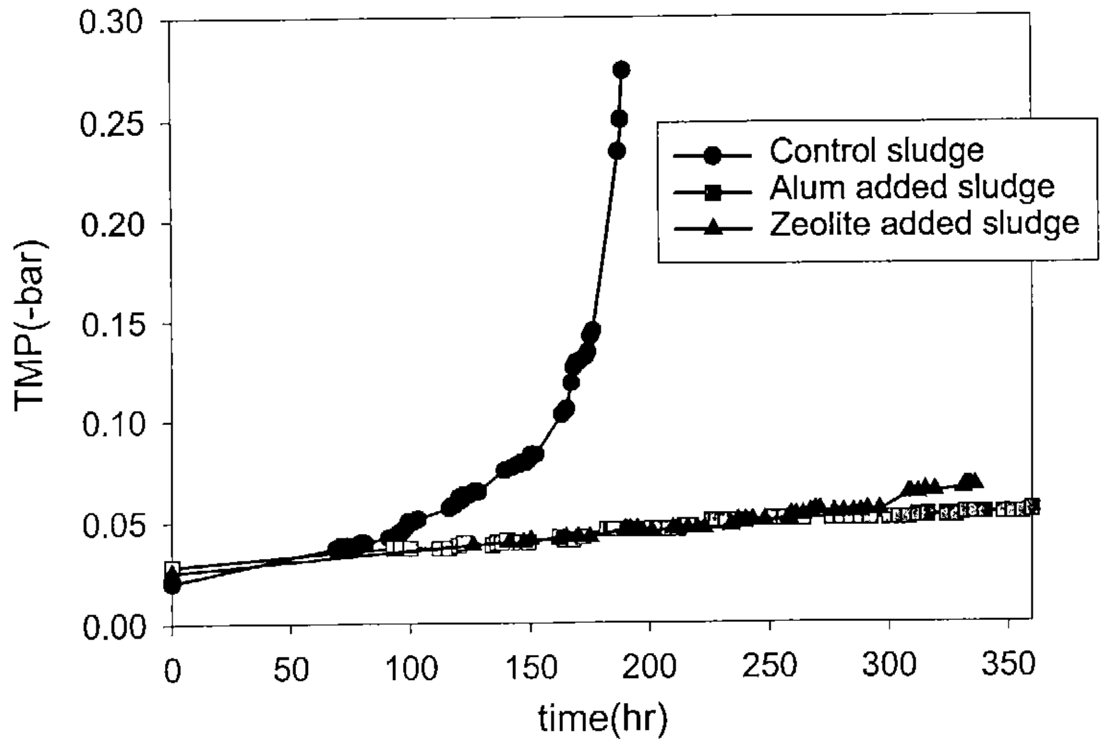
첨가제 투여 방법

Alum 투여 : Al^{3+} / P = 1.5, 연속적 투여
Zeolite 투여 : 1000 mg/L, 부착성장 유도

운전조건

분리막 성상(HF, 560cm2), Flux(15L/m2/hr), HRT(6hr)
SRT(40day), Temp(25°C), DO(4-6mg/L)...
유입폐수 : COD 220, TN 36, PO4-P 10 mg/L

TMP variations of alum/zeolite added sludge



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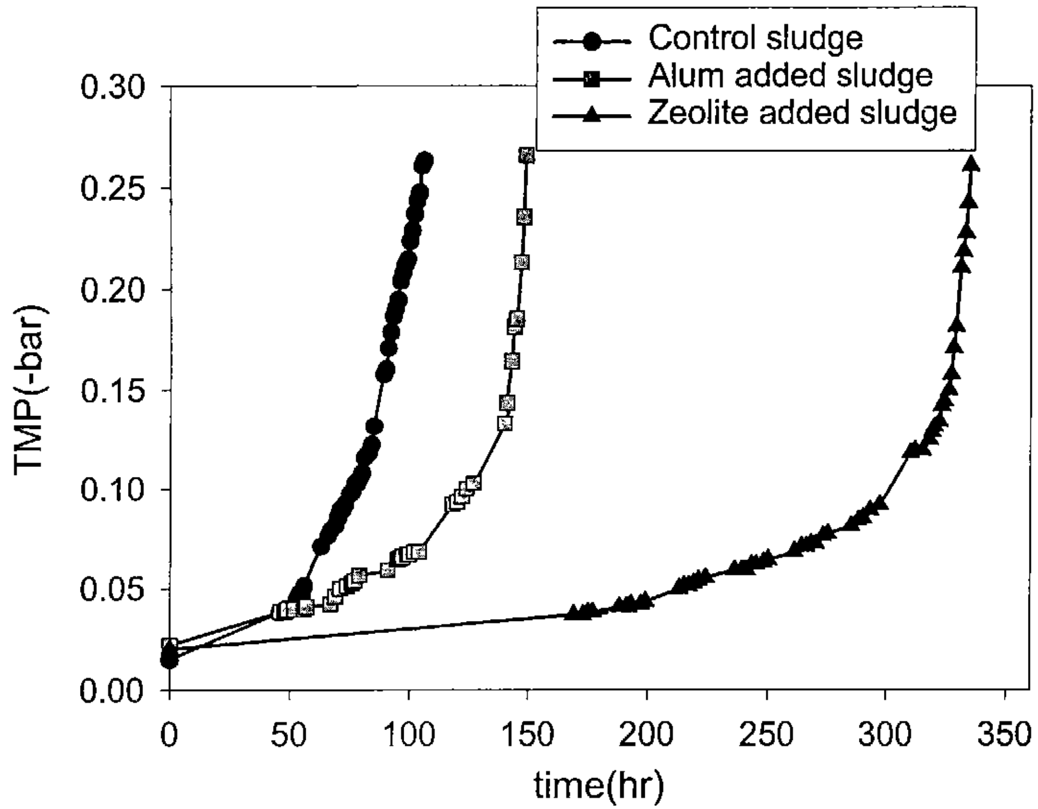
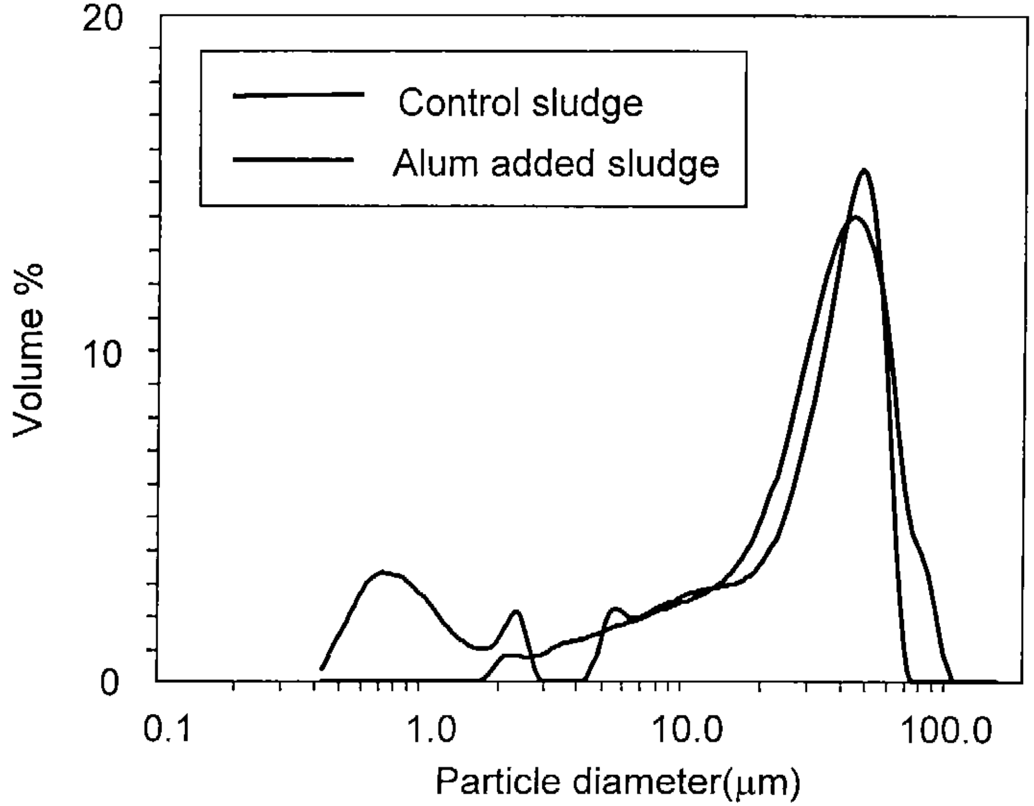
TMP variations of alum/zeolite added sludge : Shock and increased loading



Size Distributions after Alum Addition



여과특성 향상의 원인분석(Alum 첨가 경우)

Increase of particle size

: Reduced pore penetration & Enhanced backtransport

- Size distribution : not detected below 2 mm(Fig)
- Zeta potential : -14.6mV ⟶ -6.76mV

: Small Colloidal particles may be destabilized and form larger aggregates

- Reduction of Specific Resistance (more porous cake layer)
  Control sludge : $2.2*10^{13}$ m/kg
  Alum added sludge : $2.2*10^{12}$ m/kg
- Difference of Reactor COD (1.2mm GFC filter)
  and Permeate COD (0.1mm membrane)(Fig)

여과특성 향상의 원인분석(Zeolite 첨가 경우)

Change of sludge floc property

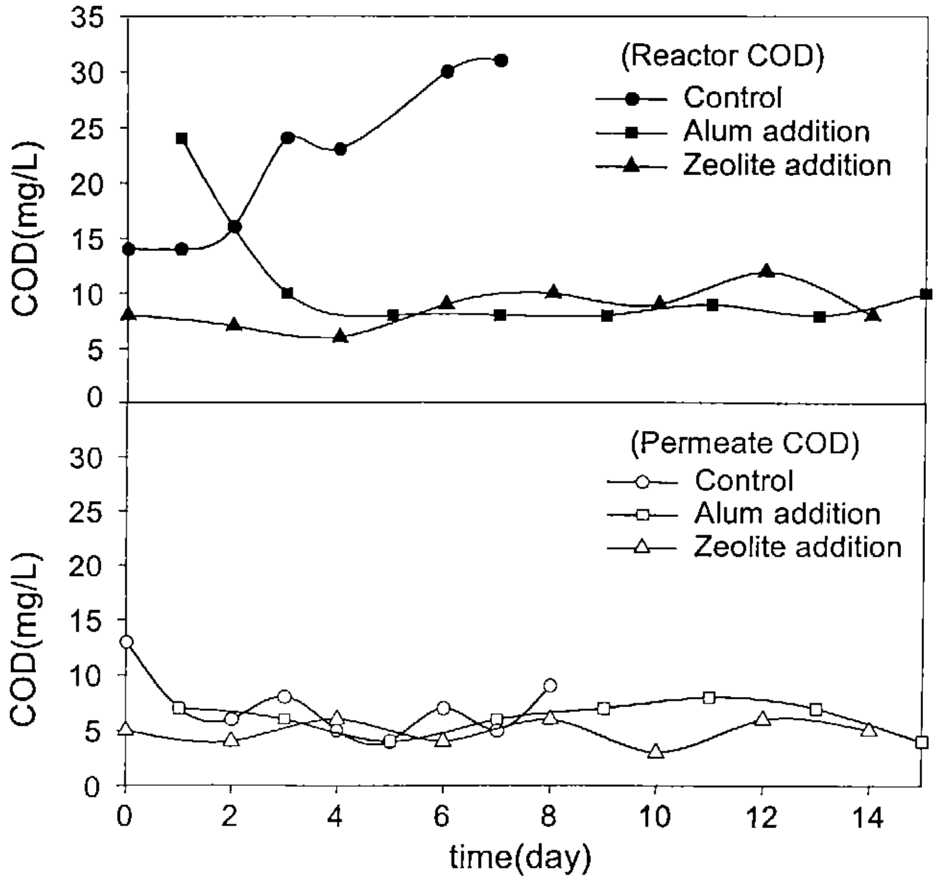
- Introduce **Attached Growth** on the Zeolite(Fig)
  : Rigid and stable flocs, better enviroment for nitrifier

- Reduction of Specific Resistance
  Control Sludge : $2.2*10^{13}$ m/kg
  Zeolite added Sludge : $6.1*10^{12}$ m/kg

- Scouring effect

- Reactor COD was small

Comparison of organic removal efficiencies between control and alum or zeolite added membrane bioreactor (loading 0.88 kgCOD/m3/d)

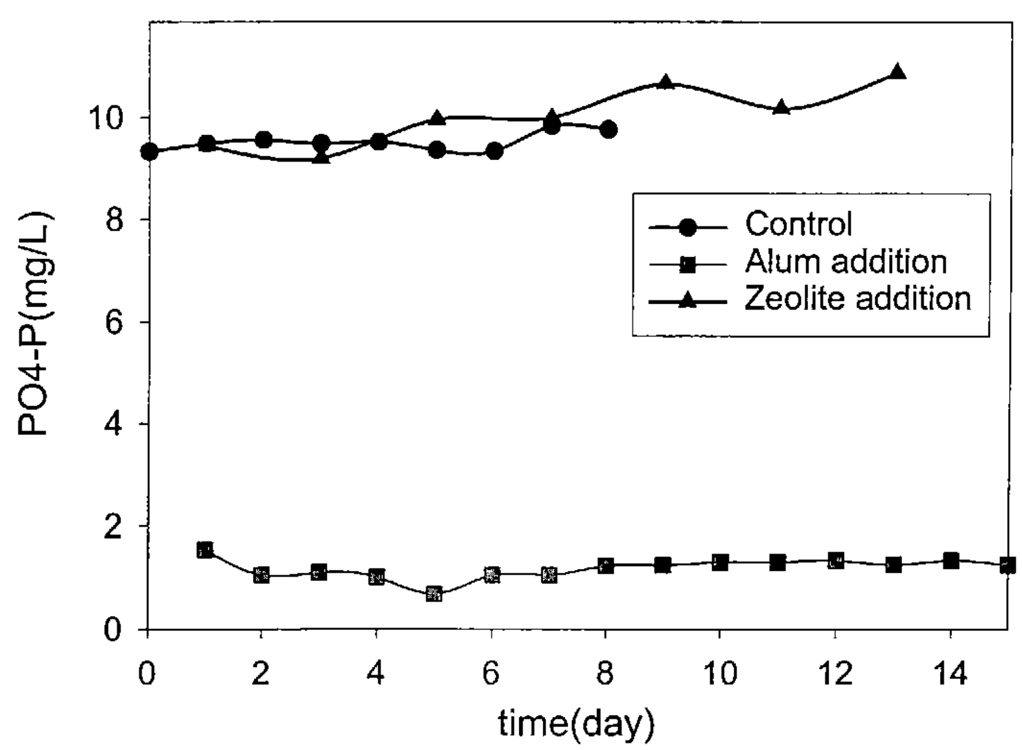


Mass balance of nitrogen during the operation of a submerged membrane bioreactor

Experimental sets	Input ($g\text{-}N/m^3day$)		Output ($g\text{-}N/m^3day$)			Nitrification rate (%)
	T-N	NH_4^+-N	NH_4^+-N	NO_3^--N	Sludge-N*	
Activated sludge	144	81	8~11	120~128	12~15	90~97
	288	162	8~16	210~240	16~20	78~88
Alum added sludge	144	81	9~16	100~120	12~14	76~92
	288	162	60~144	64~100	15~20	24~37
Zeolite added sludge	144	81	< 1	125~136	14~16	> 96
	288	162	< 3	260~280	15~23	96~99

* Loss of nitrogen by sludge wastage

Phosphorous removal in alum or zeolite added membrane bioreactor



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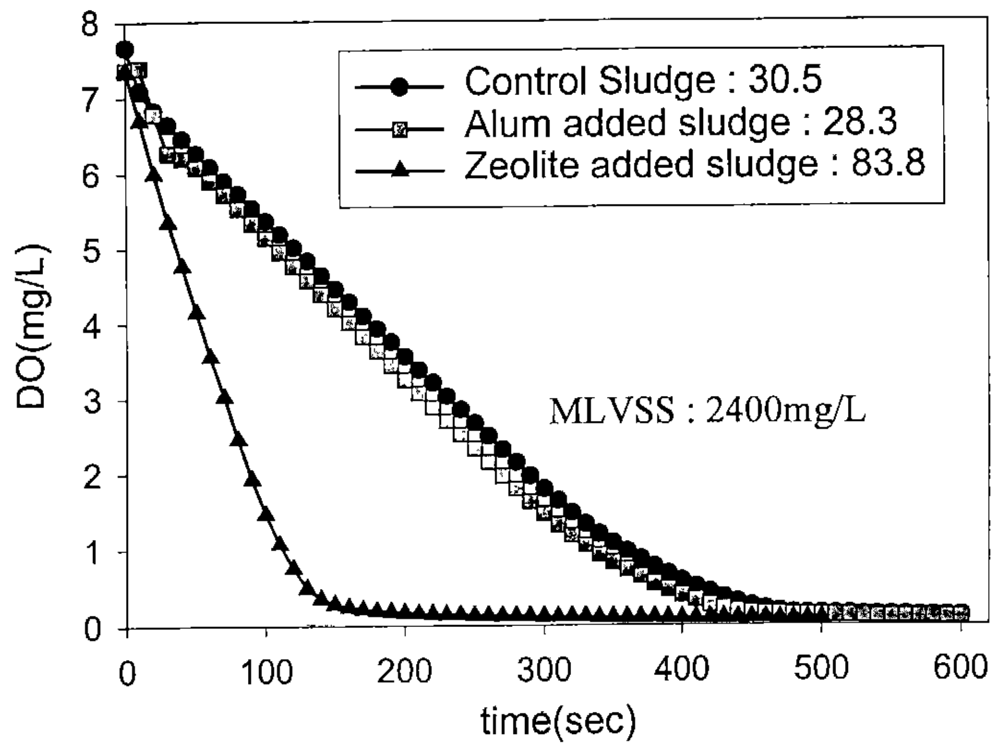
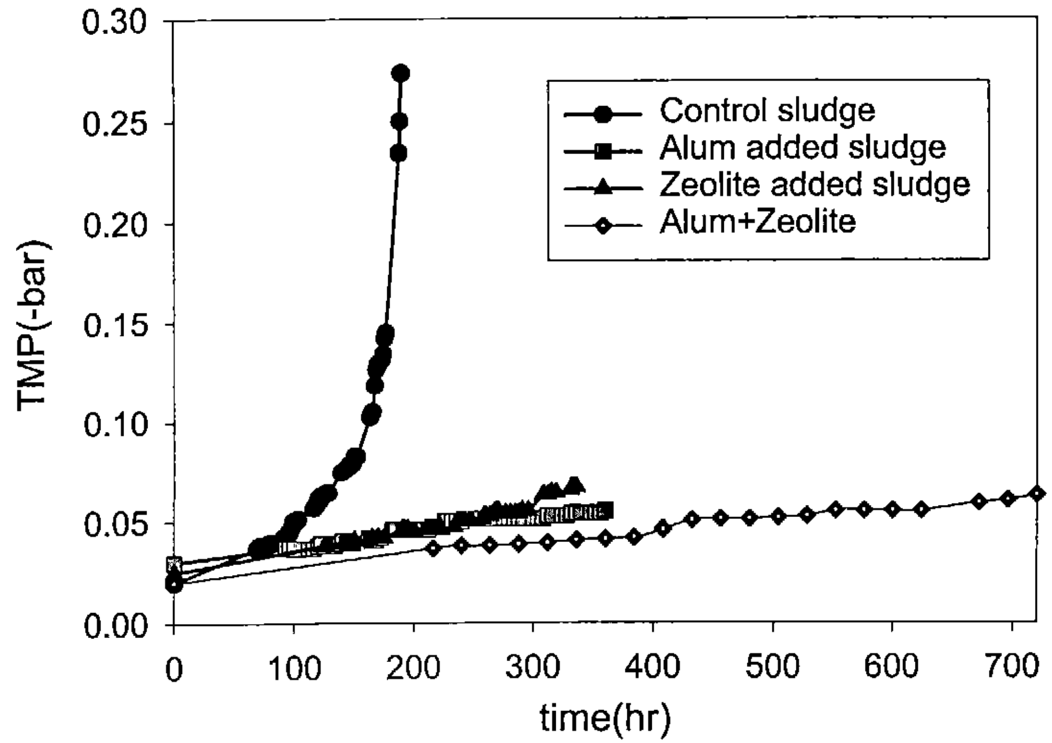
OUR of control sludge and zeolite added sludge



TMP variation of alum+zeolite added sludge



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