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แอดดิเวทเตดคาร์บอนและนาโนฟิลเตรชั่น



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COMPARISON OF HALOACETIC ACID REMOVAL BETWEEN BIOLOGICAL
ACTIVATED CARBON AND NANOFILTRATION

Miss Chalatip Ratasuk

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for the Degree of Doctor of Philosophy in Environmental Management (Inter-Department)

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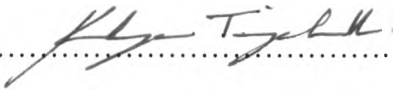
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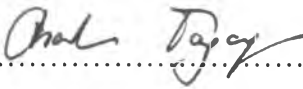
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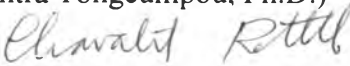
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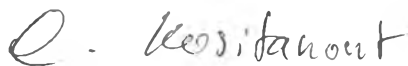
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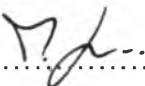
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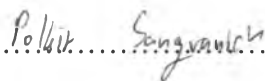
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ชลาทิพย์ รัตสุข: การเปรียบเทียบการกำจัดฮาโลอะซีติกแอซิดโดยวิธีไบโอโลจิคอลแอกติเวทเตดคาร์บอนและนาโนฟิลเตรชัน (COMPARISON OF HALOACETIC ACID REMOVAL BETWEEN BIOLOGICAL ACTIVATED CARBON AND NANOFILTRATION อาจารย์ที่ปรึกษา: ผศ. ดร.ชวลิต รัตนธรรมสกุล อาจารย์ที่ปรึกษาร่วม: Asst. Prof. Eakalak Khan, Ph.D., และ ผศ. ดร.ชาญวิทย์ โหมยิตานนท์. 119 หน้า. ISBN 974 - 53 -1318 -1.

ฮาโลอะซีติกแอซิดเป็นผลพลอยได้ที่เกิดขึ้นจากการเติมคลอรีนเพื่อฆ่าเชื้อโรคในกระบวนการผลิตน้ำประปา ซึ่งสารบางตัวมีคุณสมบัติเป็นสารก่อมะเร็ง USEPA กำหนดค่ามาตรฐานของฮาโลอะซีติกแอซิดในน้ำประปาเท่ากับ 60 ไมโครกรัมต่อลิตร และจะลดลงเหลือ 30 ไมโครกรัมต่อลิตร

งานวิจัยนี้เป็นการทดลองเพื่อศึกษาถึงการกำจัดฮาโลอะซีติกแอซิดด้วยกระบวนการนาโนฟิลเตรชัน โดยใช้เมมเบรนสามชนิด คือ ES 10, NTR 7410 และ NTR 729 HF เปรียบเทียบกับวิธีไบโอโลจิคอลแอกติเวทเตดคาร์บอน ผลการทดลองแสดงให้เห็นว่าเมมเบรน ES 10 และวิธีไบโอโลจิคอลแอกติเวทเตดคาร์บอน มีประสิทธิภาพใกล้เคียงกันในการกำจัดฮาโลอะซีติกแอซิด ที่ความเข้มข้น 60 และ 90 ไมโครกรัมต่อลิตร คือสามารถกำจัดได้ 95-100 เปอร์เซ็นต์ แต่วิธีไบโอโลจิคอลแอกติเวทเตดคาร์บอนจะมีประสิทธิภาพในการกำจัดฮาโลอะซีติกแอซิดได้มากกว่ากระบวนการนาโนฟิลเตรชันที่ความเข้มข้น 120 ไมโครกรัมต่อลิตร ปัจจัยที่มีผลต่อประสิทธิภาพการกำจัดของกระบวนการนาโนฟิลเตรชันคือ ความดัน และความเข้มข้นของสารตั้งต้น ประสิทธิภาพการกำจัดฮาโลอะซีติกแอซิดจะเพิ่มขึ้นที่ความดันและความเข้มข้นของสารตั้งต้นต่ำ สำหรับวิธีไบโอโลจิคอลแอกติเวทเตดคาร์บอนพบว่า การเติมโอโซนไม่มีผลต่อประสิทธิภาพการกำจัด โดยสามารถลดฮาโลอะซีติกแอซิดได้น้อยกว่า 20 เปอร์เซ็นต์ แต่การกรองผ่านไบโอโลจิคอลแอกติเวทเตดคาร์บอนพบว่าสามารถลดฮาโลอะซีติกแอซิดลงได้ประมาณ 80-90 เปอร์เซ็นต์ ซึ่งจากผลการทดลองสามารถสรุปได้ว่ากระบวนการกรองวิธีไบโอโลจิคอลแอกติเวทเตดคาร์บอนสามารถลดฮาโลอะซีติกแอซิดได้

สาขาวิชา การจัดการสิ่งแวดล้อม
ปีการศึกษา 2547

ลายมือชื่อนิสิต.....
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CHALATIP RATASUK: COMPARISON OF HALOACETIC ACID REMOVAL BETWEEN BIOLOGICAL ACTIVATED CARBON AND NANOFILTRATION. THESIS ADVISOR: ASST. PROF. CHAVALIT RATANATHAMSKUL, Ph.D., THESIS CO-ADVISORS: ASST. PROF. EAKALAK KHAN, Ph.D., AND ASST. PROF. CHARNWIT KOSITANONT, Ph.D., 119PP. ISBN 974 -53 -1318 -1.

Haloacetic acids are disinfection by-products generated during the chlorination process in drinking water system. Some of them are suspected human carcinogens. The U.S. Environmental Protection Agency currently limits the maximum contaminant level of sum of five haloacetic acids (HAA₅) in drinking water to 60 ppb, but will soon lower to 30 ppb in the Stage two of the Disinfectants/Disinfection By-products (D/DBP) rule. In this study the removal of 60, 90, and 120 ppb HAA₅ from aqueous solutions using batch scale nanofiltration (NF) using three membranes, ES 10, NTR 7410, and NTR 729 HF and ozone-biological activated carbon (BAC) methods were evaluated and compared.

NF using ES 10 membrane and the ozone-BAC system are comparable in removing HAA₅ at concentrations of 60 and 90 ppb (95-100% removal). Ozone-BAC, however, is more superior at the higher feed concentration of 120 ppb. The performance of the NF membrane was regulated by the operating pressure and concentration of HAA₅ in feed water. Better HAA₅ removal was attained at low operating pressure and low feed concentration. Unlike NF, the performance of ozone-BAC system was uninterrupted by the HAA₅ concentrations. The EBCT of the BAC column was the primary controlling parameter of the system since the pretreatment using ozonation process is considered unnecessary. Less than 20 % of the initial HAA₅ was removed by the reaction with ozone. The majority of HAA₅ (80-90%) was biodegraded in the BAC column. Due to a superior performance of BAC, it is expected that BAC column could be used as a standalone process to control HAA₅.

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NOMENCLATURES

A_k	ratio between pore surface area and total membrane surface area (dimensionless)
AOC	assimilable organic carbon
BAC	biologically activated carbon
C^*	average solute concentration in the membrane (mol m^{-3})
C_i	ion i concentration in the system film±membrane (mol m^{-3})
C_{mi}	ion i concentration at the membrane surface (mol m^{-3})
$C_{_mi}$	ion i concentration in the membrane at the feed interface (mol m^{-3})
C_{oi}	ion i concentration in the feed (mol m^{-3})
C_{pi}	ion i concentration in the permeate (mol m^{-3})
C^*_{pi}	ion i concentration in the membrane at the permeate interface (mol m^{-3})
D/DBPs	disinfectant/disinfection byproduct
DBPs	disinfection byproduct
D_i	diffusion coefficient of the ion i ($\text{m}^2 \text{s}^{-1}$)
EBCT	empty bed contact time
F	Faraday (=96487) (C mol^{-1})
F_d	steric hindrance factor relative to diffusive (dimensionless) $(= (1-q)^2)$
F_c	steric hindrance factor relative to convection (dimensionless) $(= 2(1-q)^2 - (1-q)^4)$
$f(q)$	correction factor for wall effects inside the pore relative to diffusion (dimensionless) $(= (1 - 2.1q + 2.1q^3 - 1.7q^5 + 0.73q^6) / 1 - 0.76q^5)$
GC/ECD	gaschromatography/electron capture column
$g(q)$	correction factor for wall effects inside the pore relative to convection (dimensionless) $(= (1 - (2/3)q^2 - 0.2q^5) / 1 - 0.76q^5)$
HAAs	haloacetic acids

HAA ₅	five of the regulated haloacetic acid (monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid dibromoacetic acid)
H ₂ SO ₄	sulfuric acid
J_i	ion i flux ($\text{mol s}^{-1} \text{m}^{-2}$)
J_v	volumetric flux (m s^{-1})
K_{eff}	effective salt transfer coefficient (m s^{-1})
$K_{\text{eff}i}$	effective ion i transfer coefficient (m s^{-1})
L_p	pure water permeability ($\text{m s}^{-1} \text{Pa}^{-1}$)
M	factor relative to salt diffusion ($\text{m}^2 \text{s}^{-1}$)
M_i	factor relative to ion i diffusion ($\text{m}^2 \text{s}^{-1}$)
M'	factor relative to salt convection (dimensionless)
M'_i	factor relative to ion i convection (dimensionless)
MCLs	maximum contaminant levels
m/s	meter per second
mg/L	milligram per liter
mm	millimeter
MTBE	metyl tert butyl ether
MWCO	molecular weight cutoff
NF	nanofiltration
ppb	part per billion
p_i	ion permeability ($\text{m}^2 \text{s}^{-1}$)
ΔP	transmembrane pressure (Pa)
q	ratio between the Stokes±Einstein radius of the solute molecule to the pore radius (dimensionless)
R	perfect gas constant (=8.31) ($\text{J K}^{-1} \text{mol}^{-1}$)
R	observed salt rejection (%)
R_i	observed ion rejection (%)
T	absolute temperature (K)
USEPA	United State Environmental Protection Agency
x	distance variable (m)
Δx	capillary length (m)

Z_i	ion charge number (dimensionless)
z_i	ion i valence number (dimensionless)

Greek letters

δ	film thickness (m)
$\Delta\pi$	osmotic pressure difference (Pa)
$\Delta\Psi_D$	Donnan potential (V)
λ	membrane thickness (m)
Φ	solute transmittance (%)
Φ_i	ion transmittance (%)
Ψ	electrostatic potential of the system (V)
ω	salt permeability (m s^{-1})
ω_i	ion permeability (m s^{-1})
σ	salt reflection coefficient (dimensionless)
σ_i	ion reflection coefficient (dimensionless)