
Anaerobic Membrane Bioreactors for Treatment of Wastewater at Contingency Locations



Capt Andrew Hoisington
andrew.hoisington@usafa.edu

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Outline

- Need for wastewater treatment
- What is an MBR
- Anaerobic Process
- Characteristics of AnMBR
- Membrane Fouling
- Performance
- Energy Balance

Military Operations in the last 20 years

(deploymentlink.osd.mil, 2009)

Fort Benning Mobilization Station
US Navy 6th Fleet
US Army Southern Europe Task Force
US Marine Corps Forces Europe
US Army Europe

JTF Bravo
New Horizon

Combating Terror
In the Philippines

Operation Bright Star
Operation Atlas Response
Operation Focus Relief
Operation Restore Hope
Operation United Shield
Operation Shepherd Venue

Operation Anaconda
Operation Enduring Freedom
Operation Iraqi Freedom
Operation Desert Shield
Operation Desert Storm

US Navy 7th Fleet
US Army Pacific Deployment/Exercises



Existing Conditions, Nasiriyah Iraq



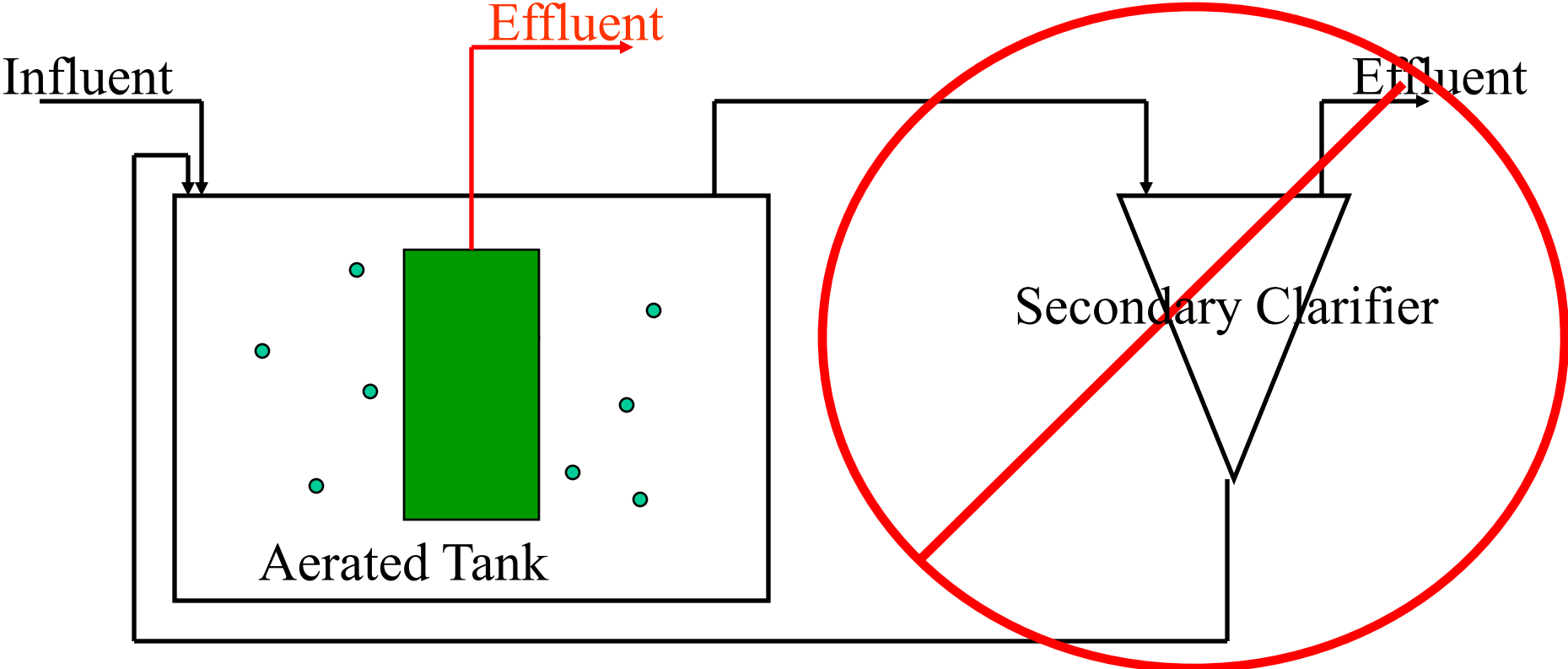
All pictures (USAID, 2009)



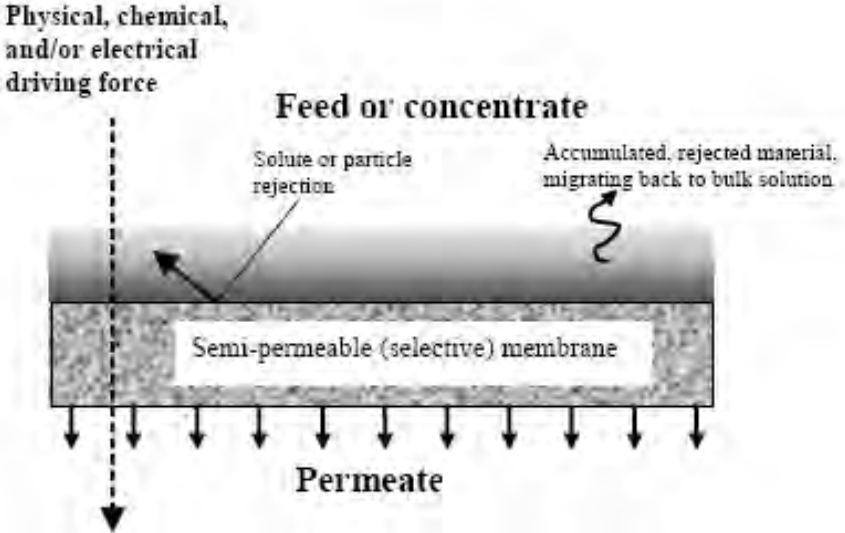
Defenselink.mil (2009)



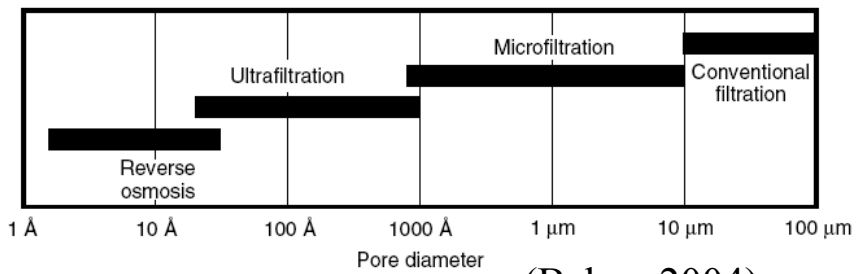
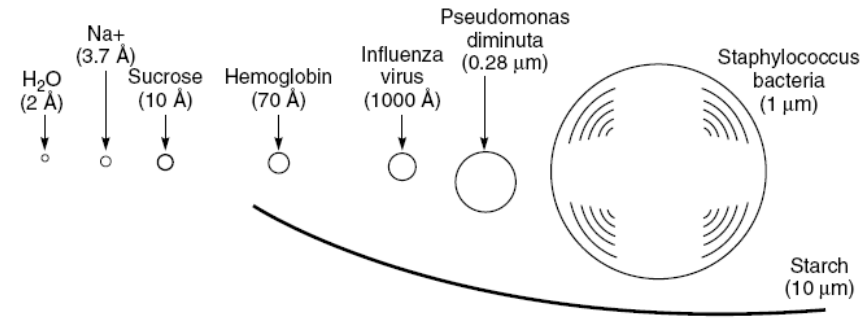
What is an MBR



Membranes



(Lawler, 2006)

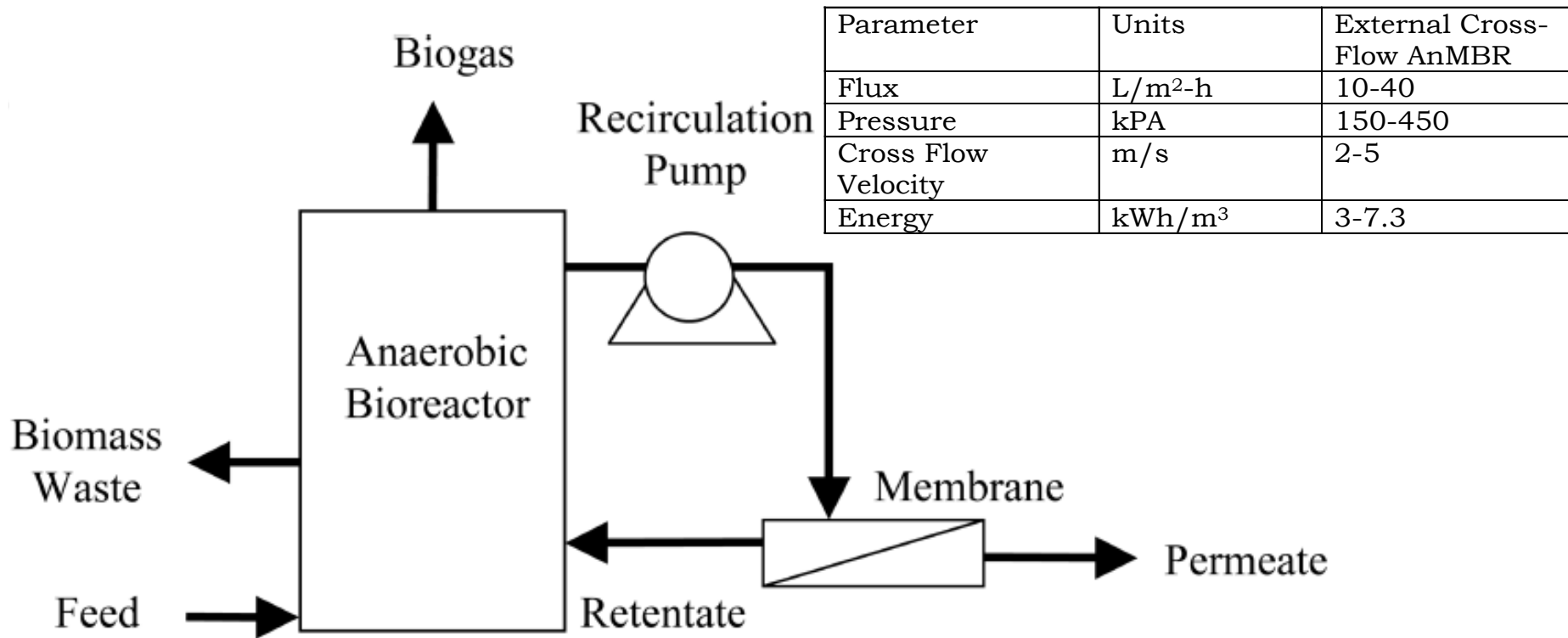


(Baker, 2004)

Anaerobic Process

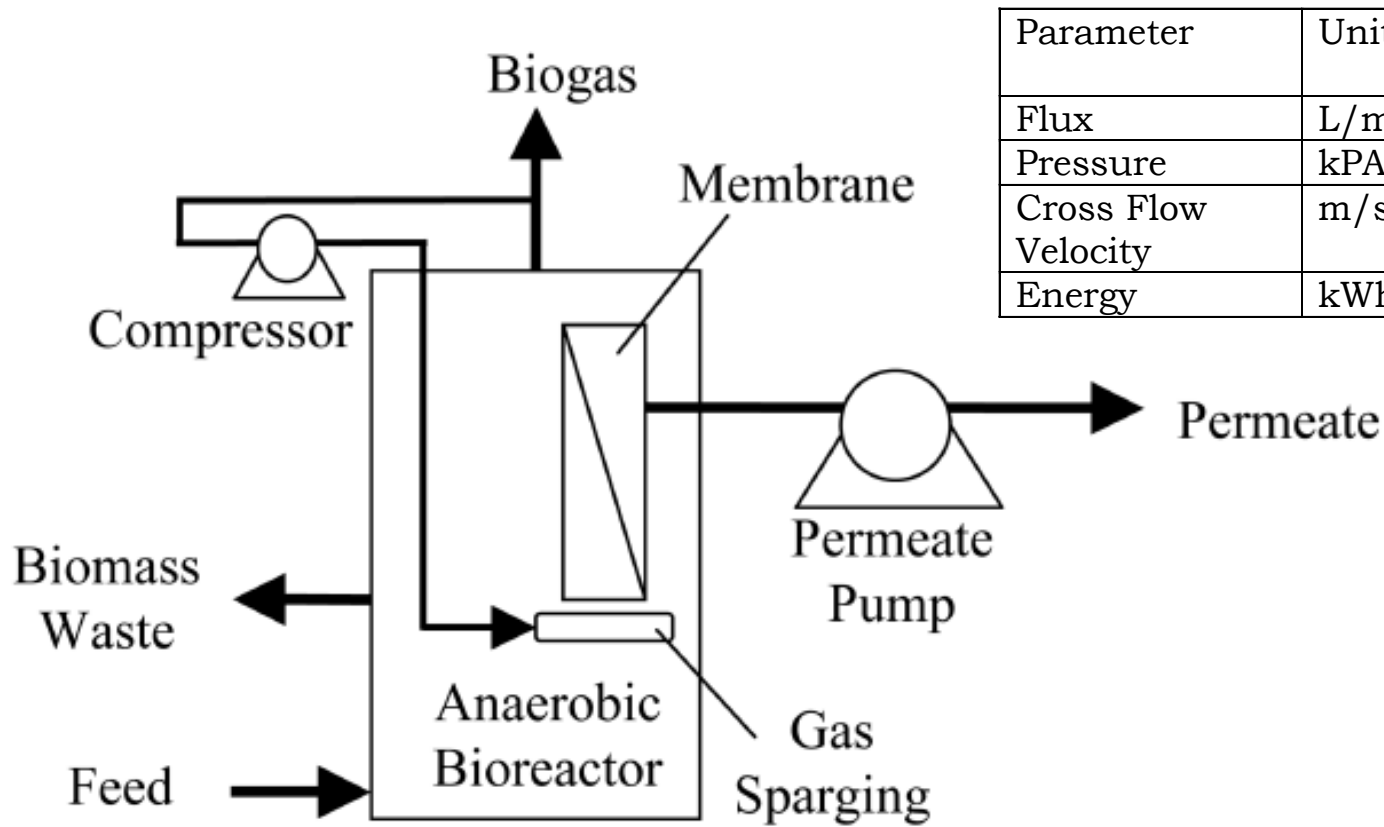
- The Good
 - lower sludge production
 - lower nutrient requirements
 - methane production
 - treats high organic concentrations
- The Bad
 - Slow growth rate of microorganisms
 - Delicate System

AnMBR Configurations – Cross Flow



(Liao, 2006)

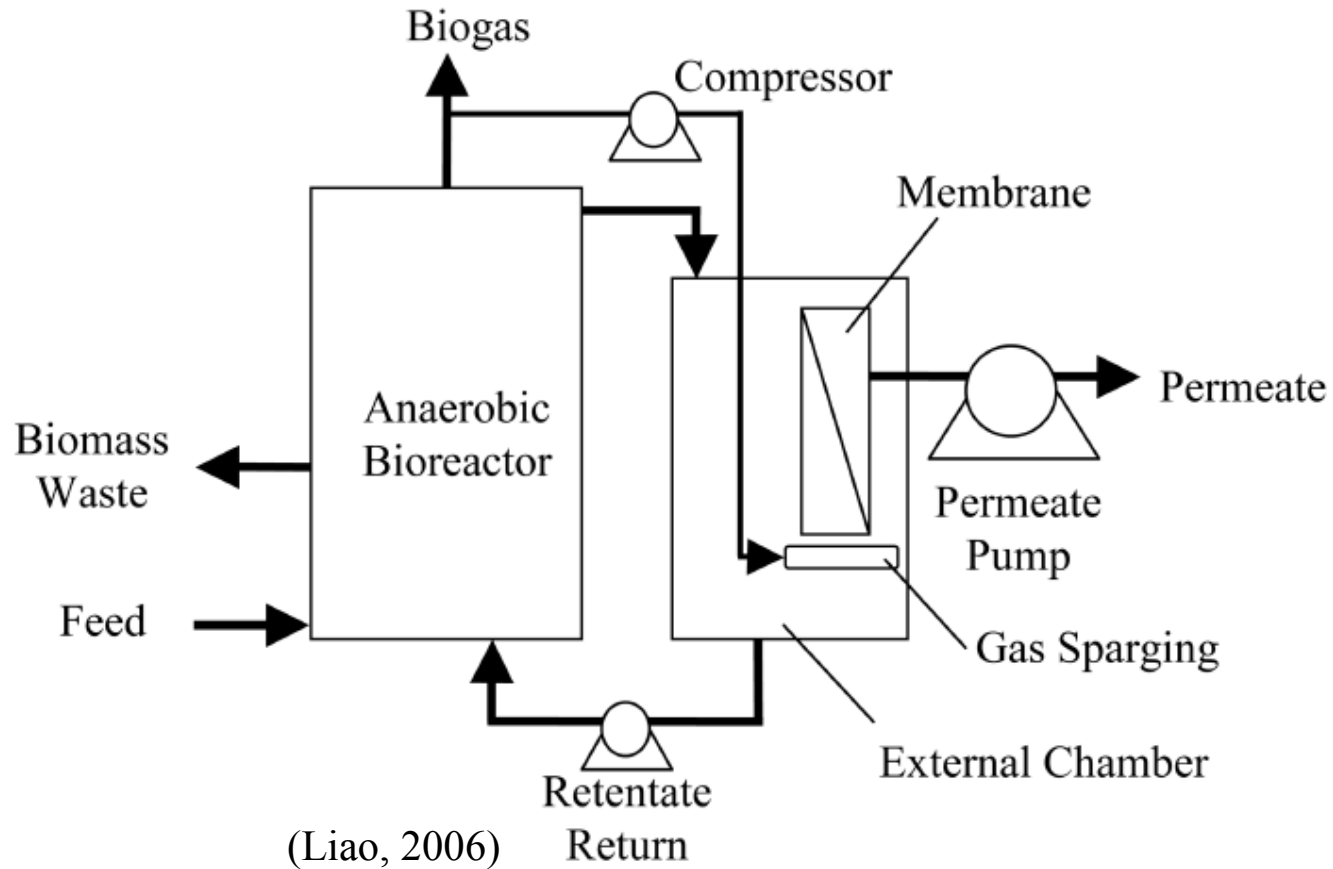
AnMBR Configurations - Submerged



Parameter	Units	Submerged AnMBR
Flux	L/m ² -h	15
Pressure	kPA	15-50
Cross Flow Velocity	m/s	N/A
Energy	kWh/m ³	0.25-1

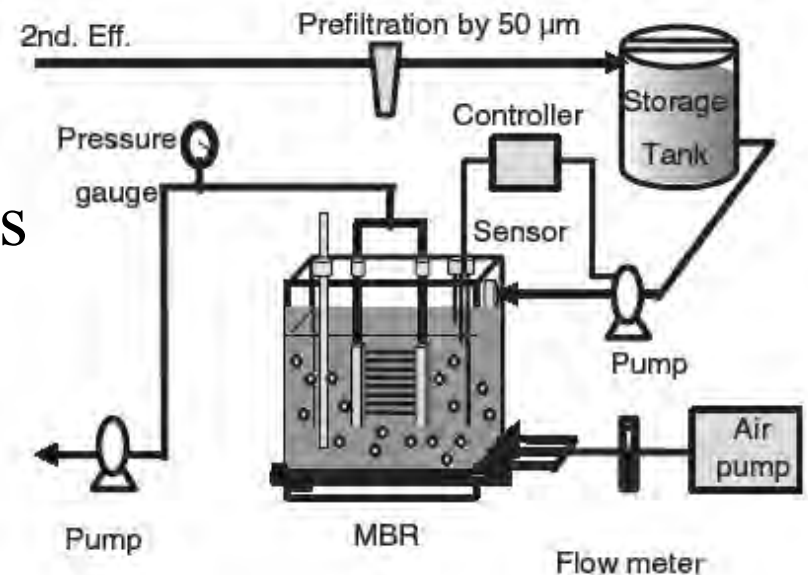
(Liao, 2006)

AnMBR Configurations – Combinations

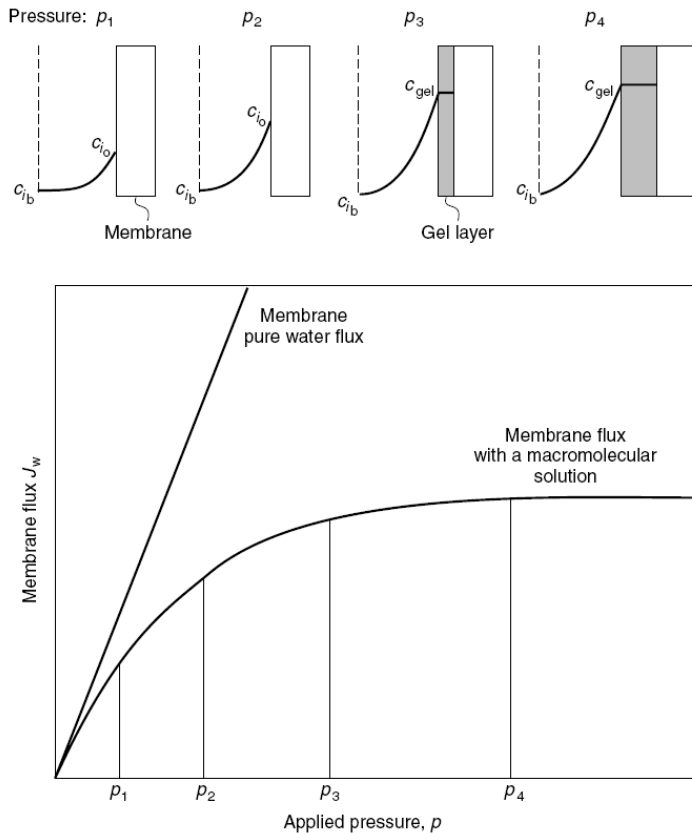


Characteristics of AnMBR

- Decoupled HRT and SRT
- Methane Production
- Capital and Maintenance Costs
- Maintenance Requirements



Membrane Fouling



(Cheryan, 1998)

$$J = \frac{\Delta P}{\mu R} = \frac{\Delta P}{\mu(R_M + R_{ir} + R_r)}$$

Membrane

Internal Clogging

External Clogging

Membrane Fouling

- Biogas sparging (submerged)
- Increase cross-flow velocity (external cross-flow)
- Backflushing
- PAC Addition
- Physical and chemical cleaning

Performance

	COD Removal Efficiency (%)	Sludge (kg produced/ kg COD removed)	Biogas (m ³ /kg COD Removed)	Effluent TSS (mg/L)
AnMBR	90+	0.0 – 0.3	0.40	>1
High Rate Anaerobic	80-90	0.1 – 0.5	0.40	30-70

Energy Balance

Assumptions:

2000 people

5% loss of methane in effluent

30-35°C reactor temperature

$$\frac{200 \text{ L}}{\text{Person} - \text{Day}}$$

$$\frac{0.4 \text{ L } CH_4}{\text{g } COD}$$

$$\frac{8.28 \text{ kw} - \text{h}}{\text{m}^3 \text{ } CH_4}$$

(Metcalf and Eddy, 2003)

Energy Production/Losses

CH₄ Production	517 kw-h
Operational Energy (Submerged)	100 - 400 kw-h
Operational Energy (Cross Flow)	1200 - 2920 kw-h

If water needs to be heated:

5°C Change	2322 kw-h
10°C Change	4645 kw-h

Questions??

