

Kinetics of Crossflow Membrane Bioreactor (CF-MBR) Processes in The Treatment of Refinery Wastewater

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OUTLINE

- Introduction
- Research Objectives
- Materials and Methods
- Results and Discussion
- Conclusion

INTRODUCTION

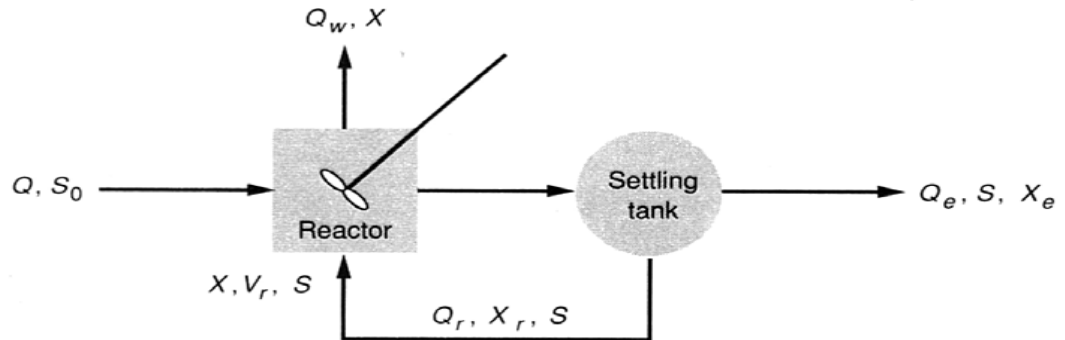
Characteristics and sources of oily waste

- Petroleum is an oily liquid, which typically contains C, H₂, S, N, O₂ and also Fe, Ca, K, Na, I, As and other element.
- The combined refinery wastes may contain
 - crude oil
 - various dissolved or suspended organic compounds discharged in liquors
 - sludges from the various stages of processing
- Wastes from the oil refineries comes from leaks, spills, tank draw-off, and other sources like emulsion incident to chemical treatment and cooling waters.

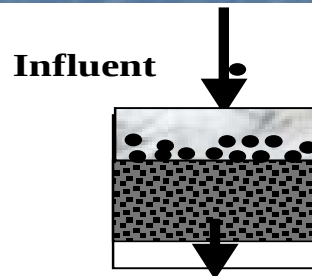
Introduction (Cont'd)

Basics of CF-MBR Process

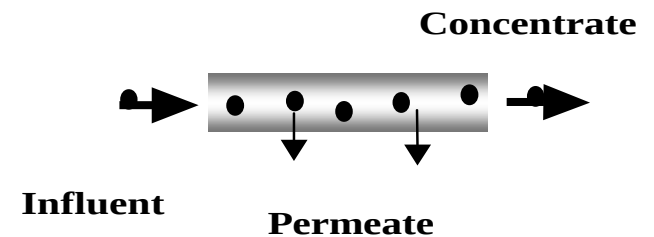
- Activated Sludge Process



- Cross Flow Filtration

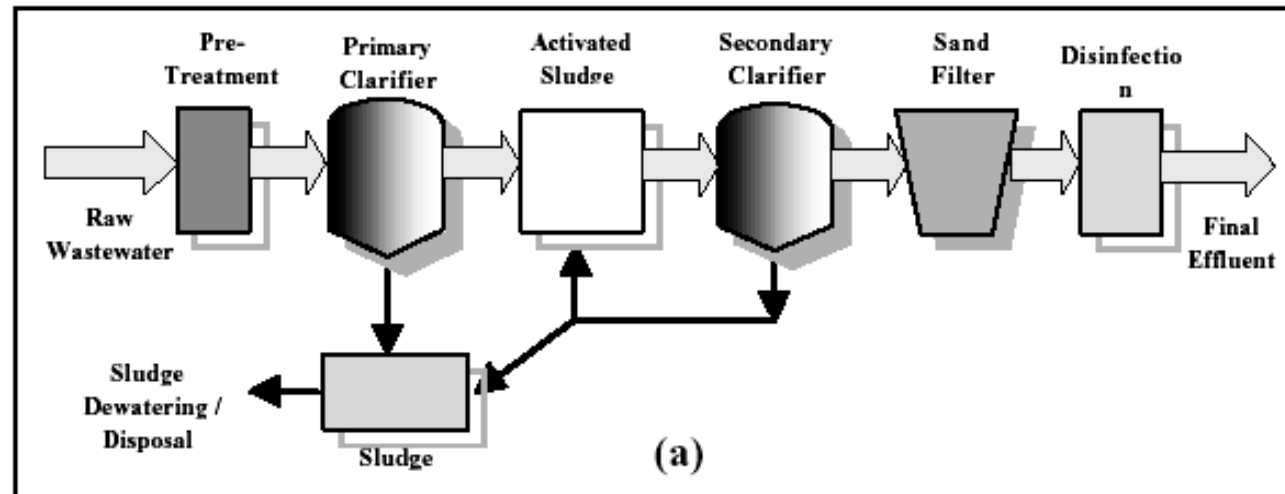


Filtrate
Dead-end Filtration

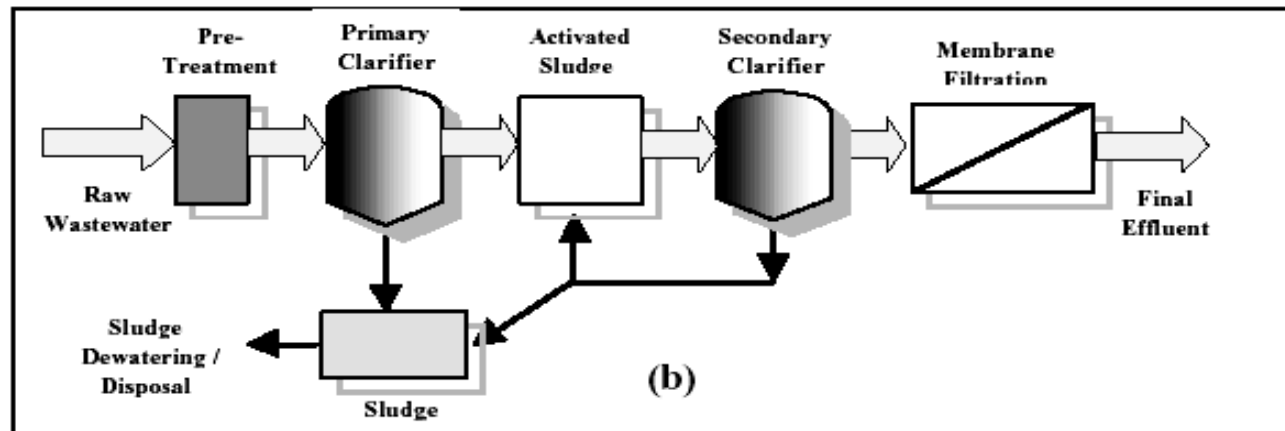


Permeate
Crossflow Filtration

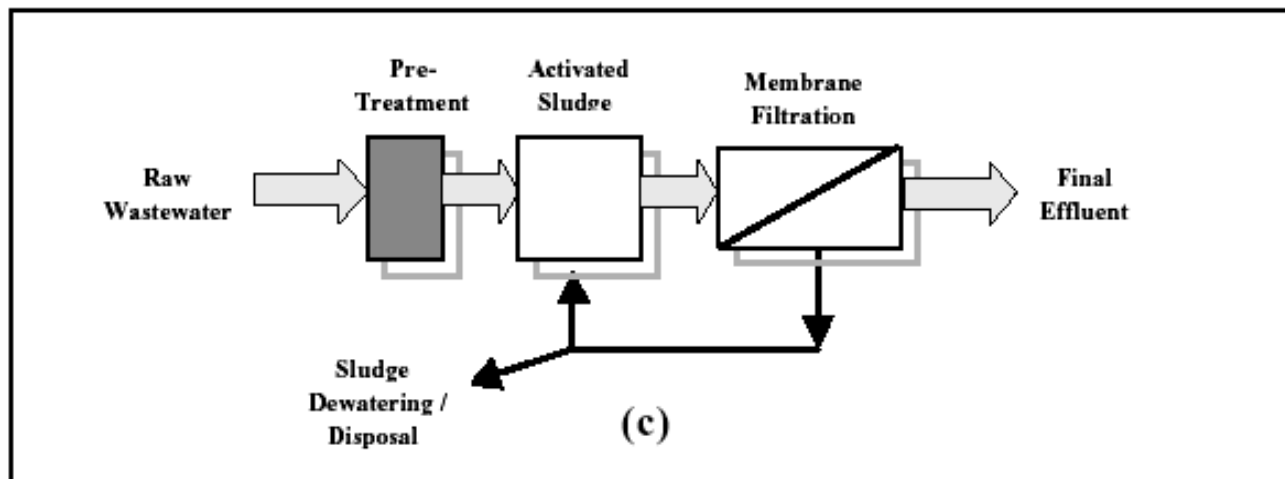
Conventional
wastewater
treatment



Conventional
treatment with
tertiary membrane
filtration



Treatment with
membrane
bioreactor



Introduction (Cont'd)

Biochemical Kinetics of MBR System

- Kinetic study of MBR is needed to understand the interaction between biological and filtration unit
- Basic Equations are based on Monod (1949) equation
- Major factors affecting the biokinetic coefficients are
(Rozich and Gaudy, 1992)
 - Reactor growth rate
 - Waste composition
 - Temperature
 - Population diversity

Introduction (Cont'd)

Substrate	Basis of analysis	Y (mg/mg)	k_d (day ⁻¹)	μ_m (day ⁻¹)	K_s (mg /l)	Treatment system	Ref
Municipal waste	COD	0.5-0.62	0.025-0.48	7.4-18.5	11-181	ASP	Gaudy & Gaudy, 1980
Municipal waste	COD	0.4-0.8	0.025-0.075	2-10	15-70	ASP	Metcalf & Eddy, 1991
Municipal waste	COD	0.48-0.6	0.05-0.16	5.6-8.10	250-3720	CF-ASP	El-Kebir, 1991
Synthetic waste	COD	0.49-0.58	0.03-0.15	1.28-6.46	289-2933	SM-ASP	Kaly andurg, 2003
Industrial waste	COD	0.3-0.72	0.05-0.18	0.47-1.07	850-5200	ASP	Suman Raj, 2004

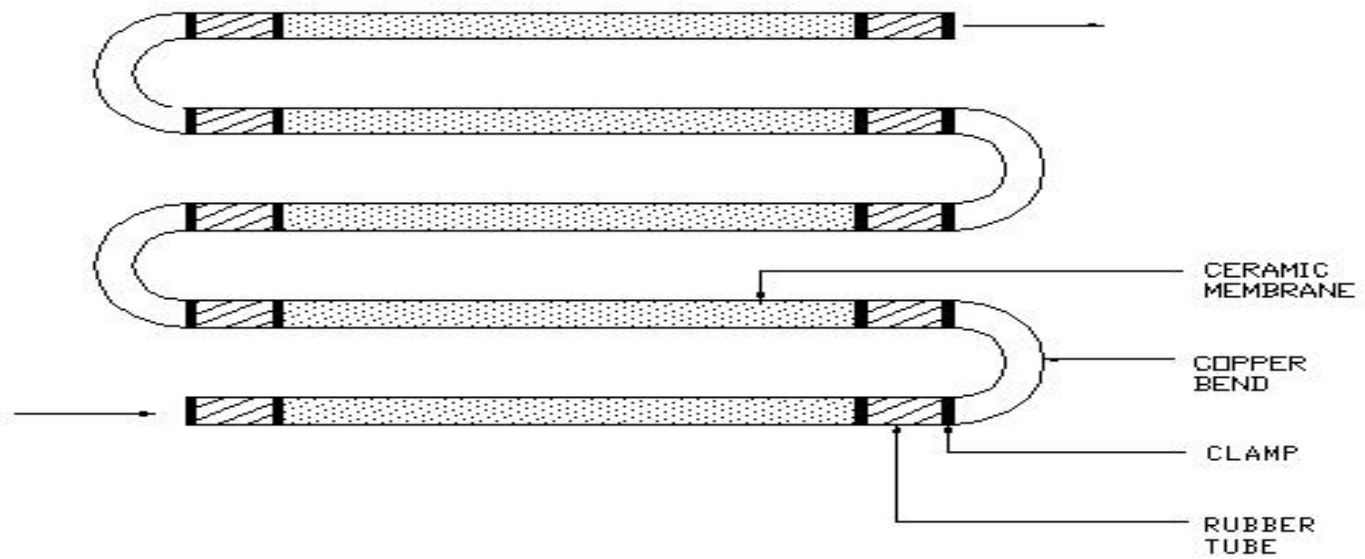
RESEARCH OBJECTIVES

- To study the interaction between the biological and filtration unit of CF-MBR at MLSS concentration of 3000 mg/l. For this purpose following biokinetic coefficients were determined:
 - saturation constant (K_s)
 - specific growth rate (μ)
 - yield coefficient (Y) and
 - endogenous decay coefficient (k_d)

MATERIALS AND METHODS

Membrane Characteristics

Configuration	Hollow Tubular ceramic membrane
Material	Alumina
Pore size	0.2 μm
Outer diameter	10 mm
Inner diameter	7 mm
Length	5 x 20 cm
Cross-sectional area	38.5 mm ²
Total Surface area	0.022 m ²
Effective Surface area	0.019 m ²
Maximum Thermal stability	120 ^o C
Maximum Filtration pressure	15 bar
pH Range	1-14

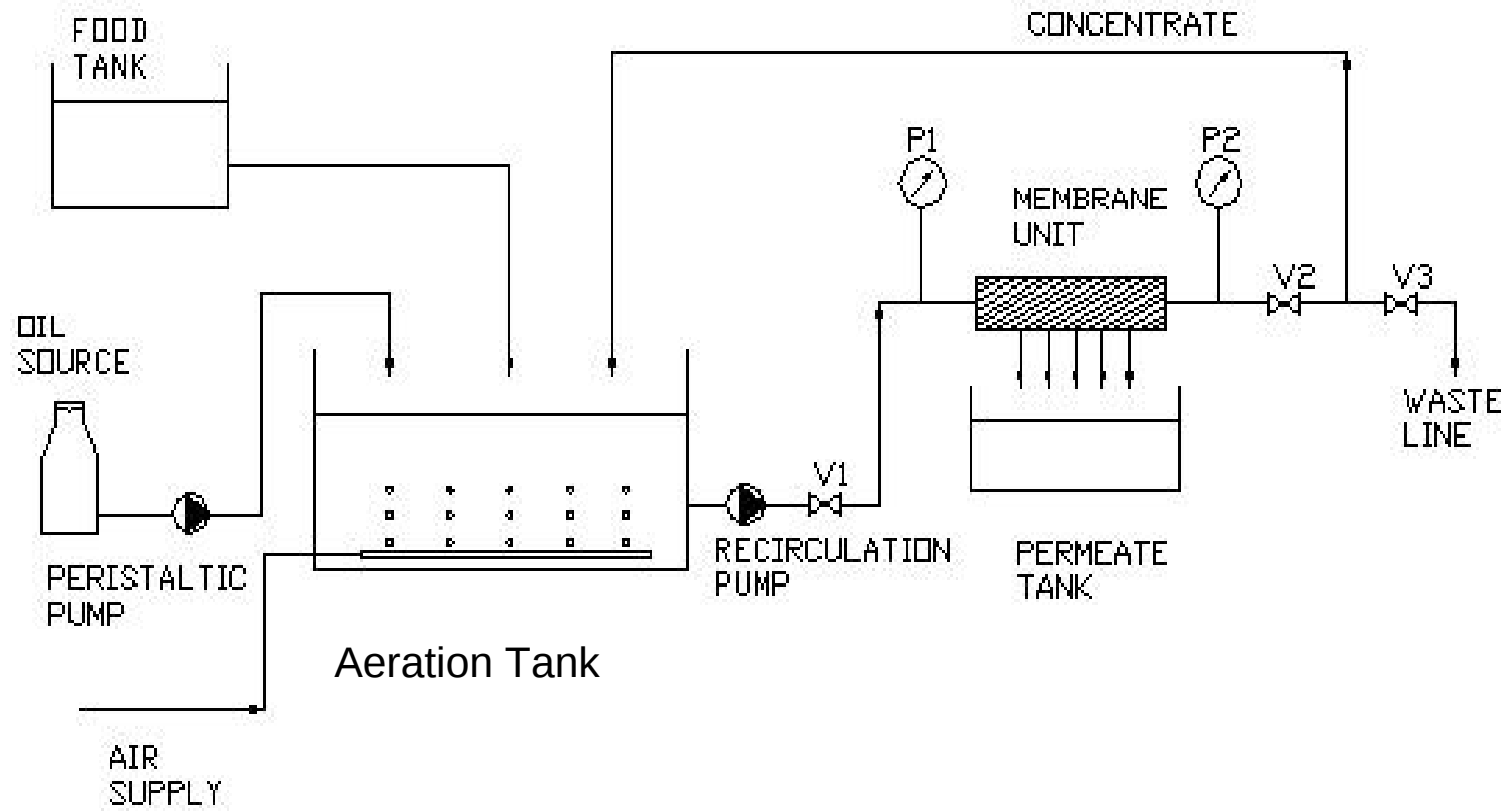


Materials and Methods (Cont'd)

Influent Substrate

- The oily waste was collected from a petroleum refinery
- The oil content was 160×10^3 mg/l
- The COD varied from 0.37×10^6 to 2.3×10^6 mg/l
- Essential nutrients were added in the bioreactor consisting of glucose, peptone and east extract
- The influent COD calculation was based on the mass loading per day (gm/day) rather than the concentration (mg/l)

Experimental Procedure layout



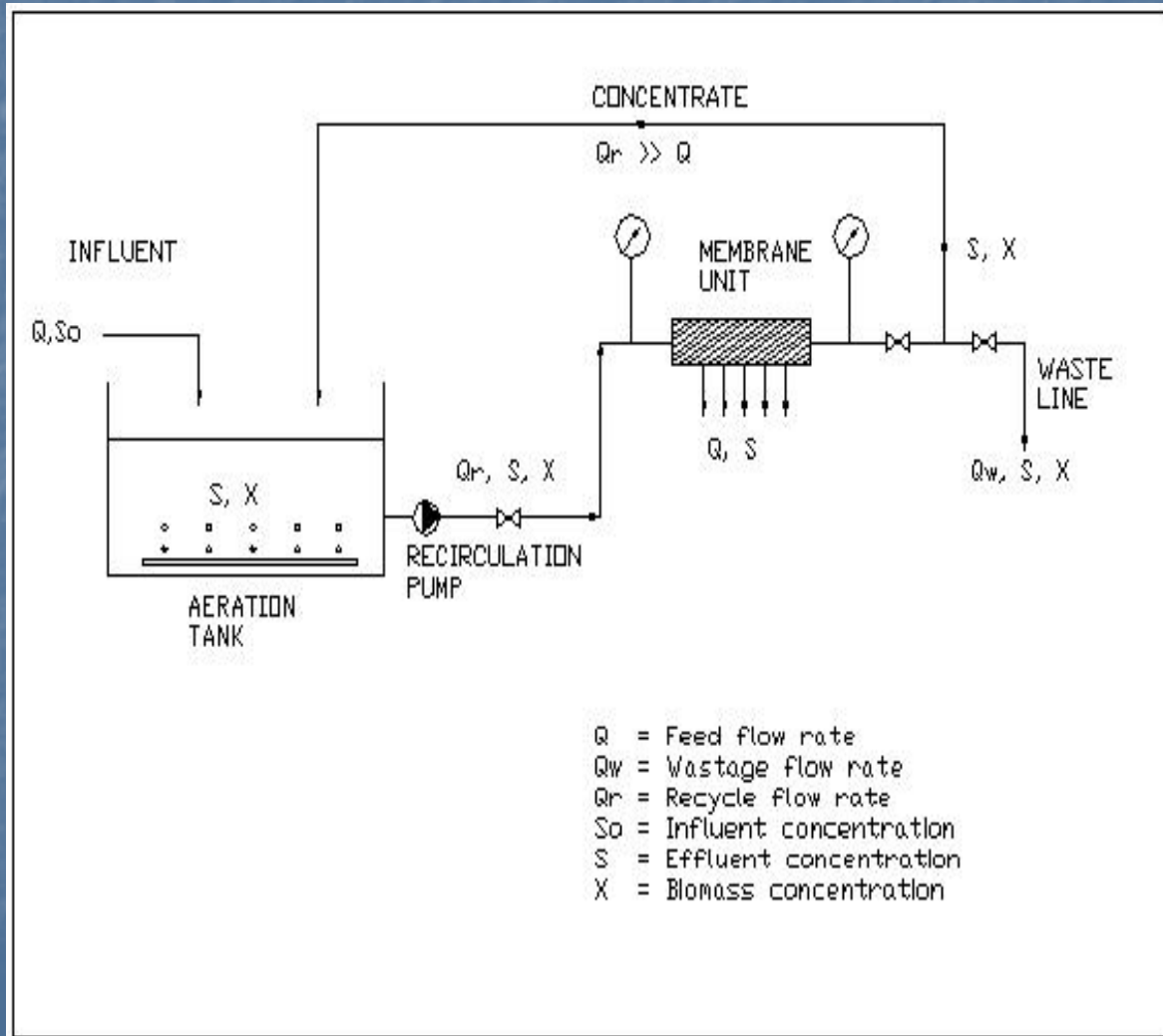


RESULTS AND DISCUSSION

Determination of Biokinetic Coefficients

Assumptions:

- Reactor is completely mixed
- Reactor volume is constant
- Complete rejection of MLSS
- No microbial solids in influent substrate



Determination of Biokinetic Coefficients (Cont'd)

Substrate Balance

Rate of change of Substrate in the reactor = Rate of input of the feed substrate - Rate of removal due to biomass utilization - Rate of removal due to washout - Substrate lost during Deliberate wastage

$$V \frac{dS}{dt} = QS_0 - \mu \frac{XV}{Y} - S(Q - Q_w) - Q_w S$$

$$\frac{Q}{VX} (S_0 - S) = \frac{1}{Y} \frac{1}{SRT} + \frac{k_d}{Y}$$

For steady state condition

Determination of Biokinetic Coefficients (Cont'd)

Biomass Balance

Rate of change of biomass in the reactor = Rate of increase due to growth - Rate of loss due to endogenous respiration - Deliberate wastage

$$V \frac{dX}{dt} = \mu XV - k_d XV - Q_w X$$

$$\frac{SRT}{1 + (SRT k_d)} = \frac{K_s}{\mu_m} \left(\frac{1}{S} \right) + \frac{1}{\mu_m}$$

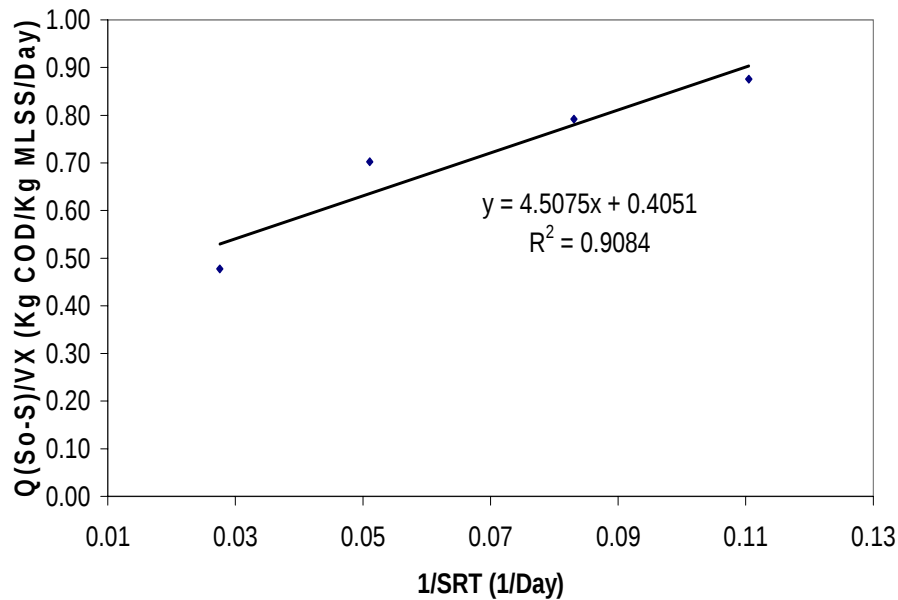
For steady state condition

Determination of Biokinetic Coefficients (Cont'd)

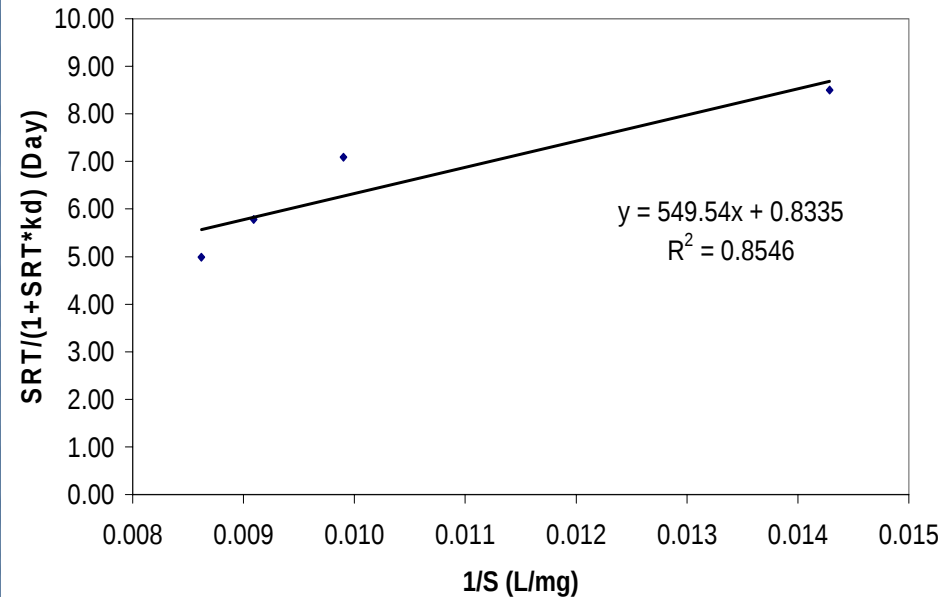
Steady state data at MLSS 3000 mg/l

Steady State Period	Q	X_{avg}	S	1/S	QS_0	QS	SRT	$Q(S_0 - S)/VX$	$SRT / (1 + SRT * k_d)$
	l/d	mg/l	mg/l	l/mg	gm/d	gm/d	day	1/d	day
6-9	27	3547	70	0.0143	35.775	1.918	36.25	0.48	8.5
22-25	22	3184	101	0.0099	46.966	2.241	19.58	0.70	7.09
32-34	25	3224	110	0.0091	53.775	2.724	12.04	0.79	5.78
43-46	28	3382	116	0.0086	62.545	3.292	9.05	0.88	4.99

Determination of Biokinetic Coefficients (Cont'd)



Determination of Y and k_d at
MLSS 3000 mg/l



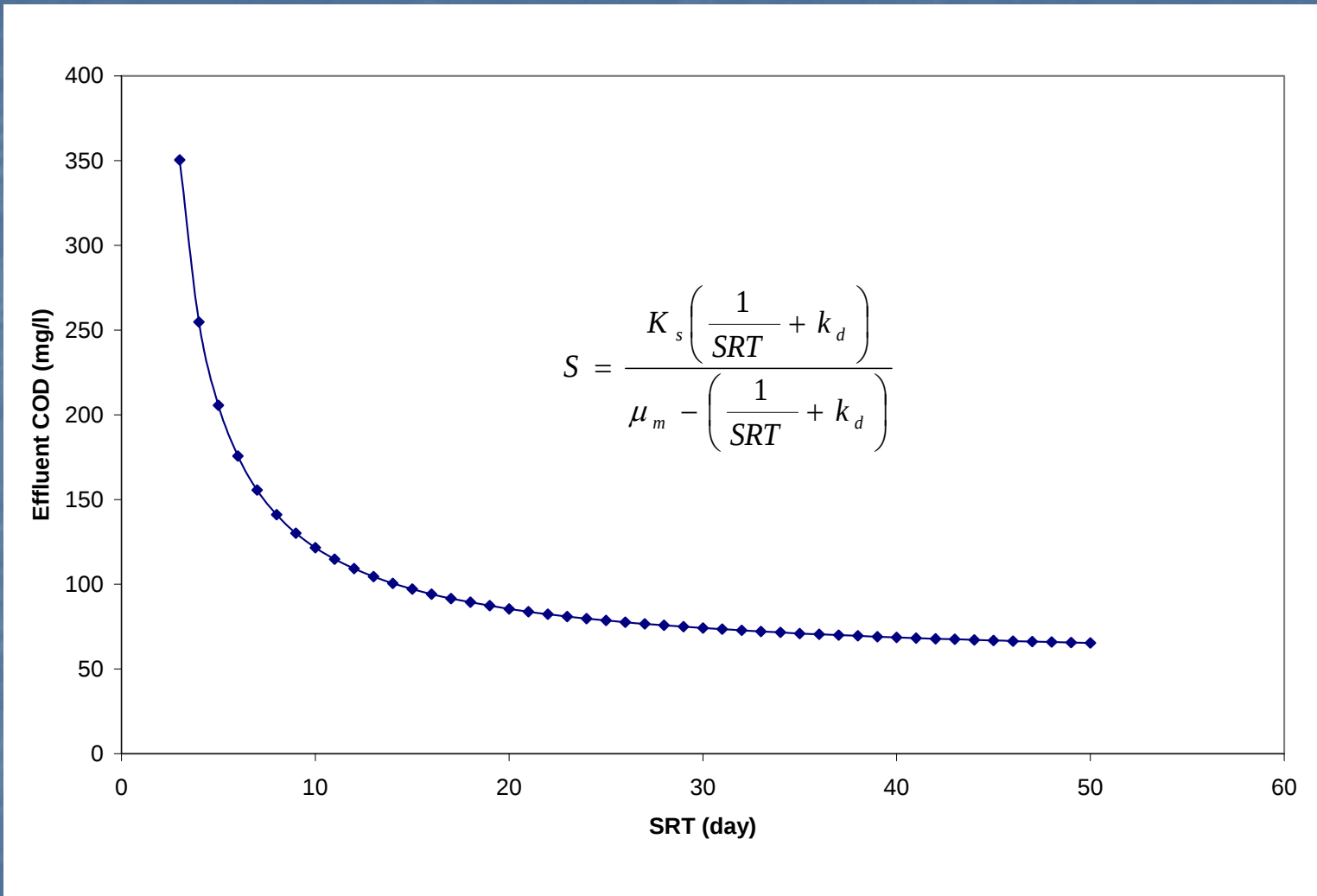
Determination of μ_m and K_s at
MLSS 3000 mg/l

Determination of Biokinetic Coefficients (Cont'd)

Summary of Kinetic Coefficients for CF-MBR at MLSS concentration of 3000 mg/l

MLSS, mg/l	Y (mg/mg)	k_d (day ⁻¹)	μ_m (day ⁻¹)	K_s (mg COD/l)
3000	0.222	0.09	1.2	659.45

Relationship Between Effluent COD and SRT



Simulated Effluent COD for MLSS concentration of 3000 mg/l

CONCLUSION

- Kinetic coefficients Y , k_d , μ_m and K_S were evaluated.
- The simulation study showed good agreement between model predictions and experimental data.
- The model can be used to simulate and investigate different operational strategies.

Thank you



Questions?

