MEPT Pilot Trial

DSD Forum 2012

Wastewater Treatment

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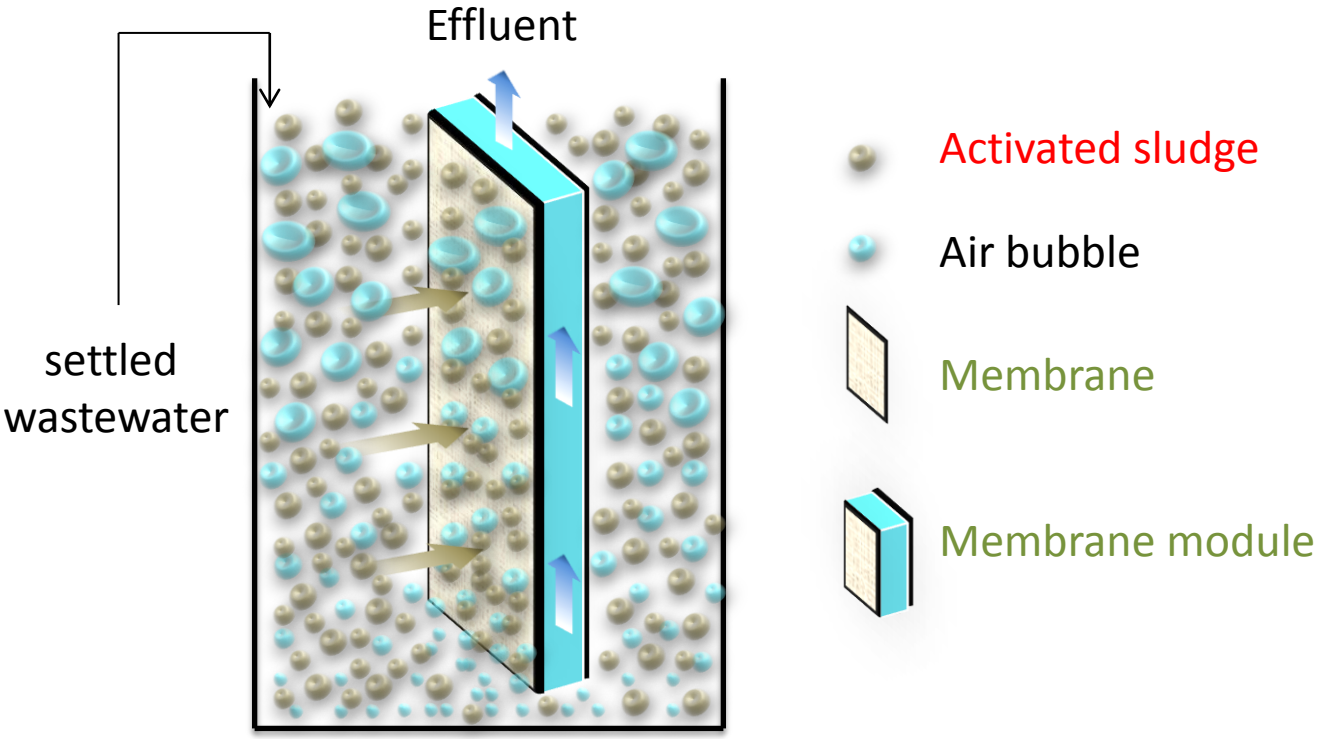
Background

Introduction of MBR and filtration technology

Membrane Bioreactor (MBR) which combines both membrane separation and biological treatment has been widely used since late 1980s.



Background

MBR VS. conventional activated sludge processes (CASP)

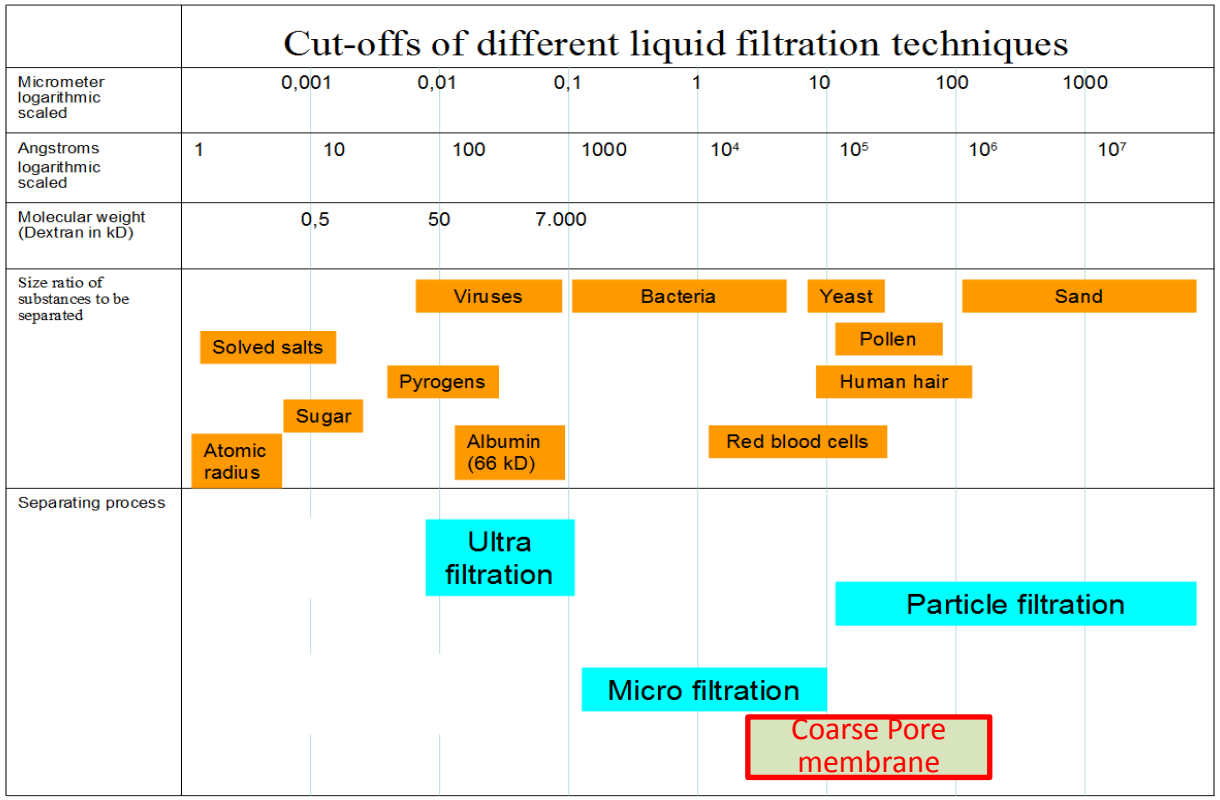
	MBR	CASP
Effluent quality	TSS<1 mg/L	TSS<30 mg/L
Footprint	~12 hr HRT	~16 hr HRT
Capacity	8-10 g/L MLSS	2-3 g/L
Sludge production	1/3 production if SRT >50	234 g/m^3 sewage treated
O&M cost	High	Acceptable

Membrane fouling → **Major problem !**

Background

Classification of MBR (cont.)

Membrane pore size: Micro filtration (MF): 0.0.1-0.4 μm; Ultra filtration (UF): 0.01 –0.1 μm;



Background

CP-MBR (HKUST MBR) V.S. conventional MBR

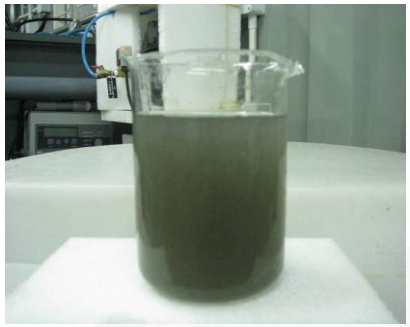
	CP-MBR	Conventional MBR
Effluent quality	TSS<15 mg/L	TSS<1 mg/L
Flux	2 – 10 m/d	0.24 - 0.72 m/d
No fouling period	12 months	2-3 months
Backwash	No chemical cleaning but 3-min backwash/~48 hrs	chemical cleaning plus routine Backwash sometime
O&M cost	Low membrane cost	Chemical, membrane cost

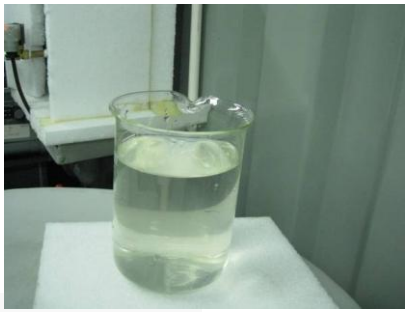
Development of HKUSTMBR

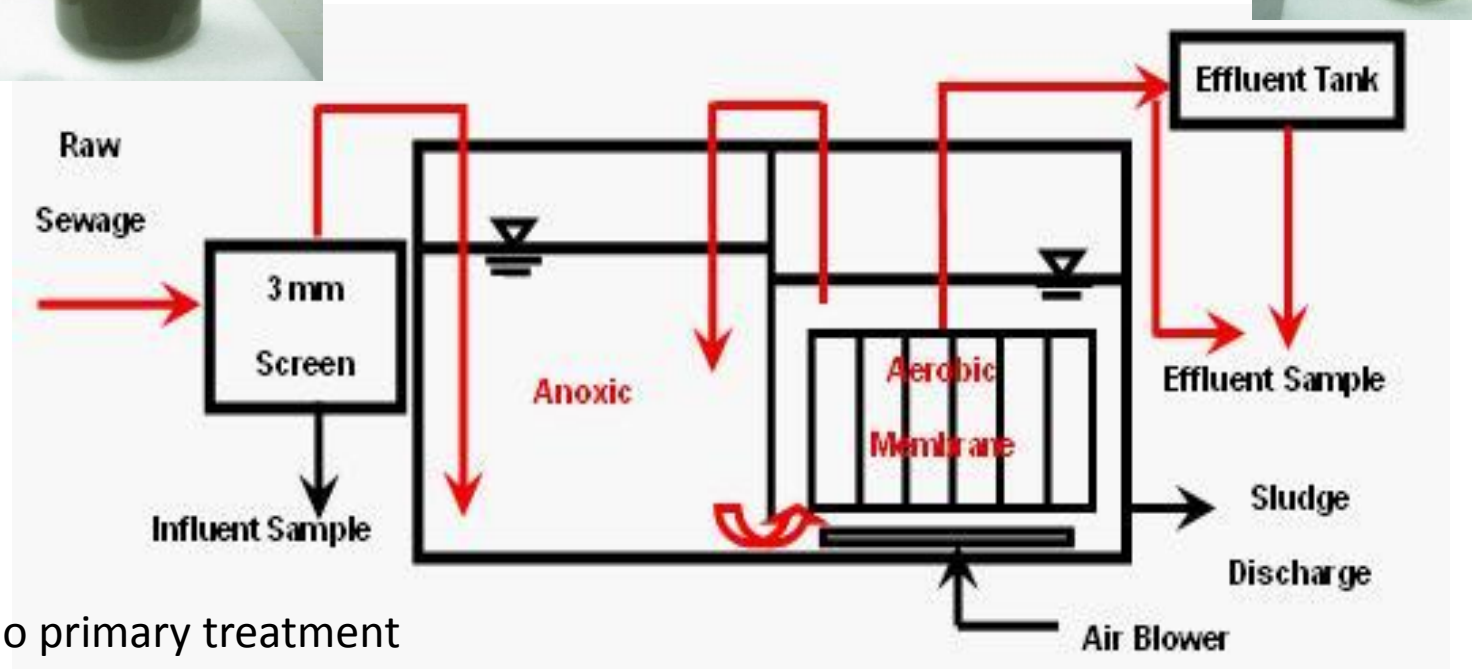
Pilot plant at HKUST (since 2008)

- After 4-yr lab study, we developed a surface processed coarse membrane in flat sheet type module in 2007.
- It has been trialed with screened saline sewage (2-7 m^3/day) since 2008 Jan.

Development of HKUSTMBR



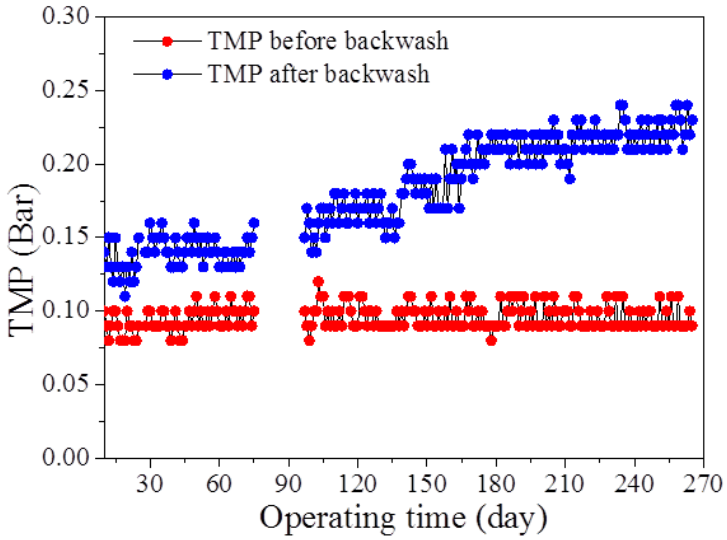




No primary treatment

Development of HKUSTMBR

Operation conditions	Unit	Value
Hydraulic retention time (HRT)	hrs	5.5
Sludge retention time (SRT)	days	33
Flux	m/d	3
MLSS concentration	g/L	2.6-3.4
Temperature	^{o}C	22-32
pH	-	6.7
DO concentration in aerobic tank	mg/L	2.8
DO concentration in anoxic tank	mg/L	0.4
Recirculation flow ratio	-	3



TSS, TKN, Ammonia, COD, BOD removal all > 90%

The system was stably operated for 270 days without membrane fouling and sludge withdrawn.

Development of MEPT Process

Biological Treatment

1. Good removal of TSS, BOD and Ammonia
2. Large footprint (~16 hrs)
3. High O &M cost
4. Large sludge production

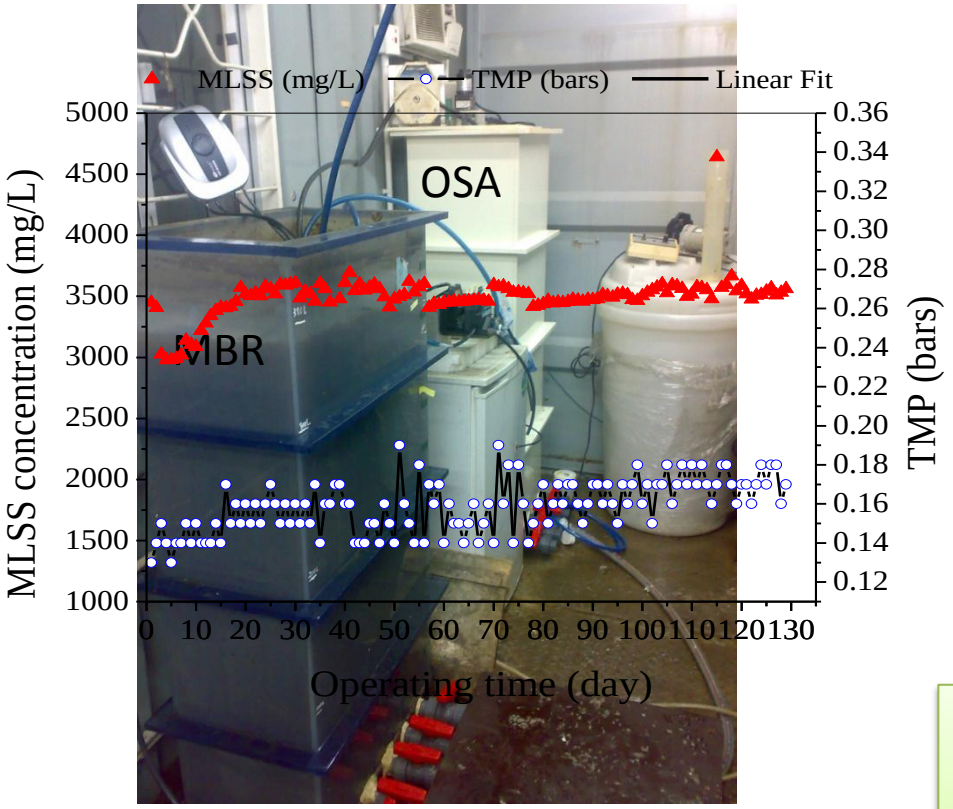
Any possible solution for upgrade of CEPT to bio-treatment without extra space?

Chemically Enhanced Primary Treatment (CEPT)

1. Little removal of soluble BOD and ammonia
2. Small footprint (~4 hr HRT)
3. Low E&M cost

Membrane Enhanced Primary Treatment: MEPT may offer one of the solutions

Small MEPT pilot-scale trial with campus sewage



Parameter	Value
Volume of aeration tank	200 L
Volume of OSA tank	200 L
HRT in aeration tank	3.6 hr
No. of membrane module	1
Flow rate	2700 L/day
Flux	~11 m/d
MLSS	around 3.5 g/L
pH	6.7
TMP	0.2 – 0.3 bar

85% TSS, 85% TCOD and 90% ammonia removal over 130 days trial within 3.6 hr HRT in total.

Large MEPT Pilot trail at Kwai Chung Industrial wastewater Pumping Station (KCIWPS)

MEPT Pilot Trial at KCIWPS

Operation condition

Phase I

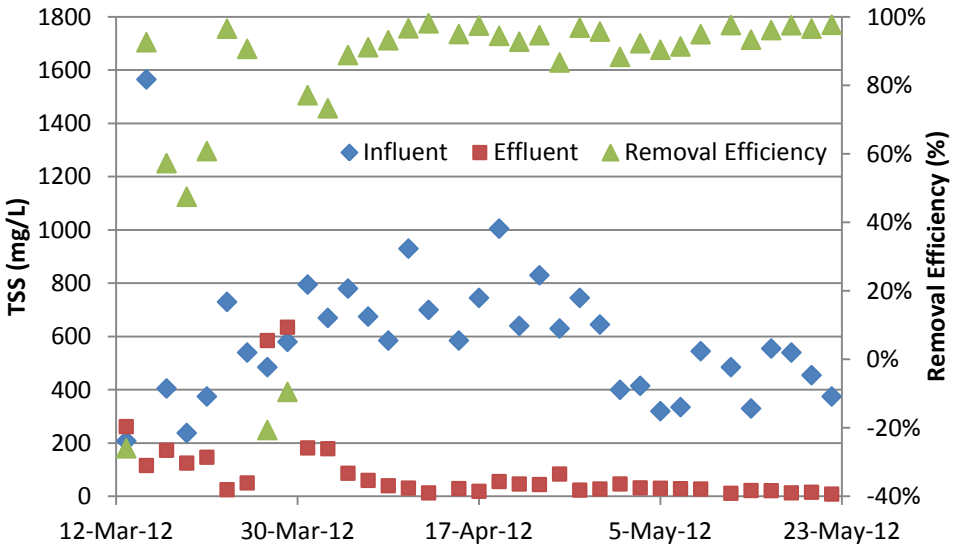
Parameter	Value
Volume of MBR tank	840 L
Volume of OSA tank	840 L
HRT in aeration tank	4 hr
No. of membrane module	10
Recirculation ratio	1
Flow rate	10 m^3/day
Flux	11.7 $m^3/m^2/d$
MLSS	around 3500 mg/L
Seeding sludge	2500 mg/L
pH	6.8~7.8
TMP	-0.01 – -0.36 bar
Temp	16~29 ^oC
Aeration	144~192 m^3/d
Air to water ratio	14~20 L of air / L of water

Phase II

Parameter	Value
Volume of MBR tank	840 L
Volume of OSA tank	840 L
HRT in aeration tank	4 hr
No. of membrane module	10
Recirculation ratio	Varied (2, 1, and 1.2)
Flow rate	10 m^3/day
Flux	11.7 $m^3/m^2/d$
MLSS	around 2000 mg/L
Seeding sludge	6000 mg/L
pH	6.8~8.1
TMP	-0.03 – -0.30 bar
Temp	28~32 ^oC
Aeration	144~192 m^3/d
Air to water ratio	14~20 L of air / L of water

MEPT Pilot Trial at KCIWPS

Phase I – MEPT performance



The MEPT process can be started up in 14 days despite strange wastewater.

New membranes installed on 13-Mar-2012

TSS removal efficiency increased to more than 90 % with < 30 mg/L of TSS in the effluent in 14 days.

One new membrane installed on 27-Mar-2012

TSS removal efficiency increased to more than 90 % with < 30 mg/L of TSS in the effluent in 14 days.

MEPT Pilot Trial at KCIWPS

Phase I – Summary

Items	Influent	Effluent	Removal Efficiency (%)
TSS	586 ± 187	28.8 ± 17.5	94.3 ± 3.1
SCOD	336 ± 193	54.1 ± 33.6	80.3 ± 10.6
TCOD	593 ± 288	86.0 ± 37.0	83.1 ± 8.4
BOD_5	318 ± 177	4.6 ± 2.9	98.2 ± 1.4
NH_3-N	31.6 ± 13.7	1.38 ± 1.49	95.3 ± 5.3
NOx-N	29 ± 83	13.9 ± 9.8	---
TKN	44.6 ± 18.8	2.69 ± 1.62	93.1 ± 4.6
TN	84 ± 93	20.2 ± 9.0	63.3 ± 23.1

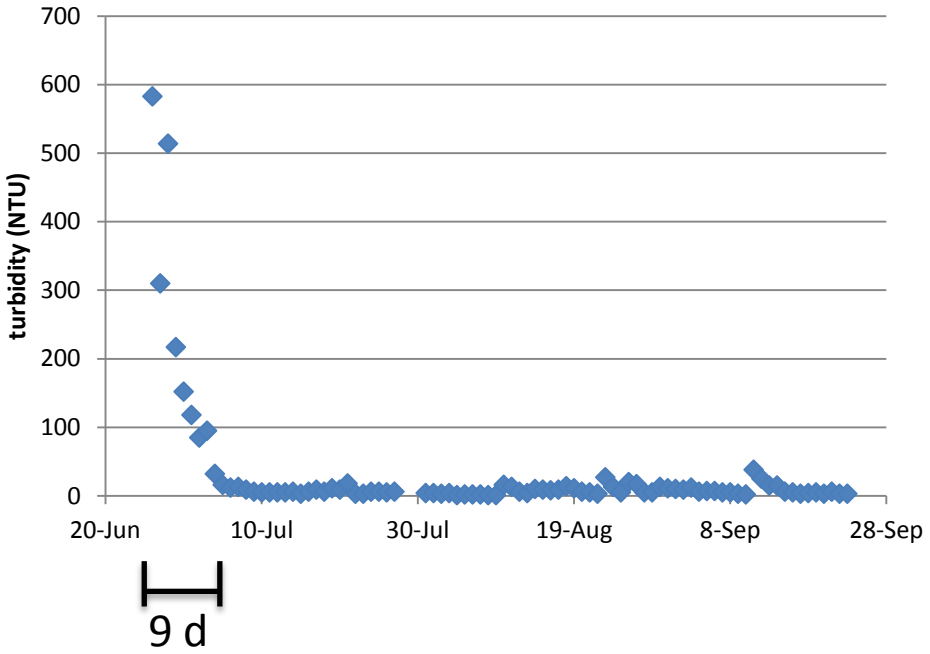
The influent quality greatly changed.

Good and stable effluent quality in terms of TSS, BOD_5, ammonia, and TKN with high removal efficiency.

High TN removal efficiency was due to the high nitrate concentration in the influent .

MEPT Pilot Trial at KCIWPS

Phase II – MEPT performance



The turbidity was monitored to ensure the successful development of the biofilm on the membrane surface, which is the start up period for MEPT process.

	Phase II	Phase I
Seeding sludge	6000 mg/L	2500 mg/L
Start-up period	9 days	14 days

Higher seeding sludge concentration can shorten the start-up period.

MEPT Pilot Trial at KCIWPS

Phase II – Summary

Items	Influent	Effluent	Removal Efficiency (%)
TSS	528 ± 157	16.6 ± 8.9	96.7 ± 2.1
SCOD	238 ± 103	54.9 ± 19.3	71.7 ± 17.9
TCOD	425 ± 144	75.7 ± 29.3	80.9 ± 8.8
BOD_5	231 ± 95	2.6 ± 1.7	98.7 ± 1.2
NH_3-N	32.5 ± 9.0	1.46 ± 1.28	95.1 ± 5.3
NOx-N	1.4 ± 2.7	18.4 ± 7.2	---
TKN	37.0 ± 10.1	3.28 ± 3.22	90.3 ± 10.8
TN	38.5 ± 10.4	21.4 ± 6.2	52.5 ± 12.0 (R=1.2)

The influent quality relatively stable comparing to Phase I.

Good and stable effluent quality in terms of TSS, BOD_5, ammonia, and TKN with higher removal efficiencies than in Phase I.

TN removal efficiency was maintained around 50% when the recirculation ratio was kept at 1.2.

MEPT Pilot Trail at KCIWPS

MEPT VS. CEPT & CASP (A/O process)

Items	MEPT		CEPT		A/O process	
	Effluent (mg/L)	Removal (%)	Effluent (mg/L)	Removal (%)	Effluent (mg/L)	Removal (%)
TSS	16.6 ± 8.9	96.7 ± 2.1	~100	82	~30	92
TCOD	75.7 ± 29.3	80.9 ± 8.8	~180	52	< 50	90
NH_3-N	1.46 ± 1.28	95.1 ± 5.3	~20	10	< 5	95
TN	21.4 ± 6.2	52.5 ± 12.0	~20	N.A.	~ 15	~ 50%
HRT	4 hr		2-3 hr		~16 hr	
sewage	municipal & industrial		Municipal		Municipal	

MEPT vs. CEPT

Much higher removal efficiency with a little bit longer HRT.

MEPT vs. CAST

Much lower HRT with almost the same or even higher removal efficiency.

Effluent Samples of Phases I and II

Influent

Phase I - effluent

Phase II - effluent

MEPT Pilot Trial at KCIWPS

Conclusions

The MEPT process can be continuously operated under a very high-flux (11 m/d) even with greatly varying influent quality. 96.7% TSS, 98.7% BOD_5, 95.1% ammonia can be removed, with 52.5% TN removed under a recirculation ratio of 1.2.

No sludge was purposefully withdrawn in both phases with stable MLSS concentration.

MEPT system can potentially upgrade the CEPT works as well as retrofit conventional s2nd sewage treatment works for space saving.