Pre-treatment of municipal wastewater using direct ceramic membrane filtration for agricultural reuse

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Outline

- Wastewater treatment
- Direct ceramic membrane filtration
- Materials and Methods
- Results and Discussions
- Conclusions

Wastewater as a resource

~~WASTE~~?WATER

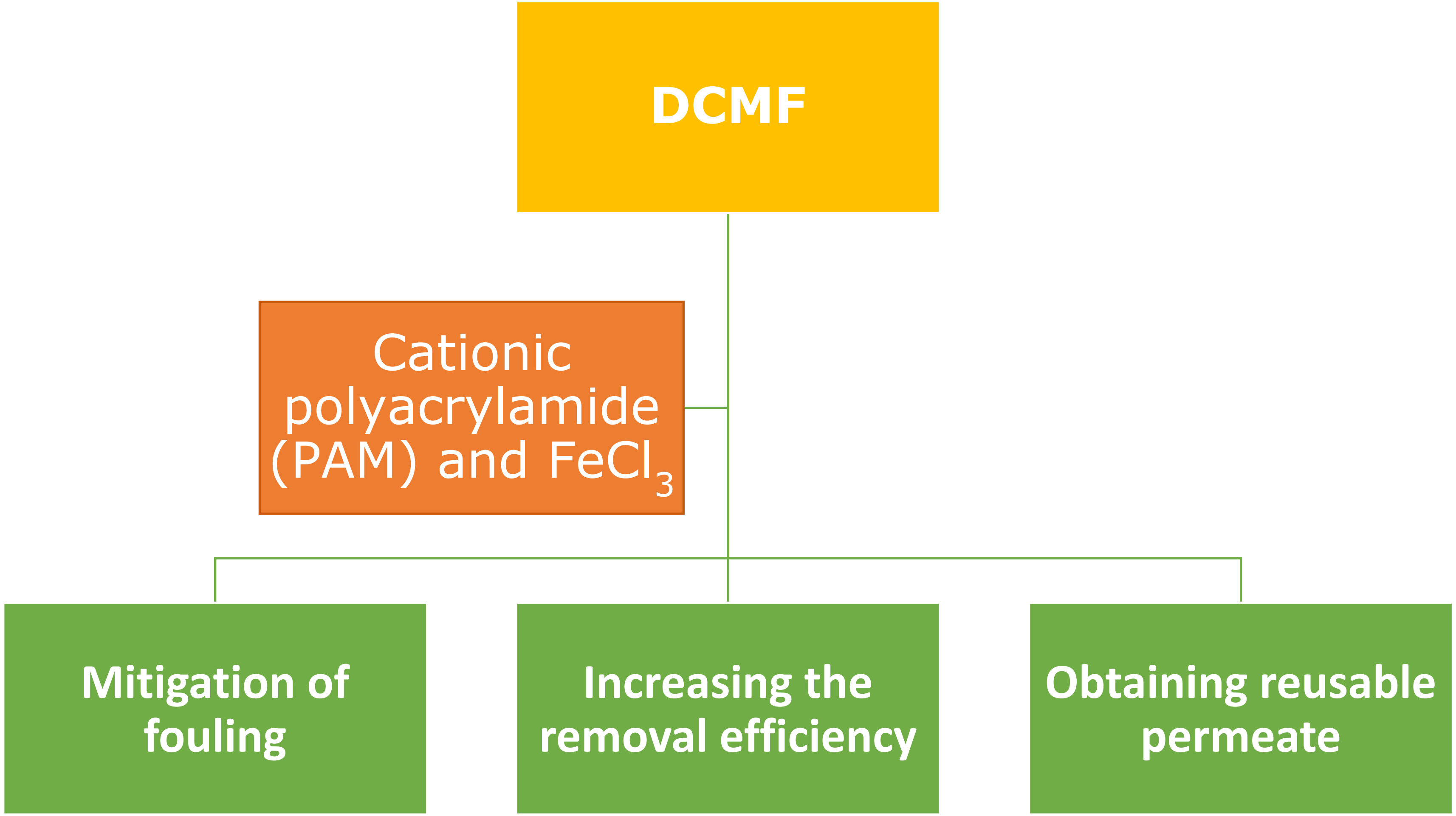
Conventional wastewater treatment processes

- Energy consumption
- High amount of sludge production
- Greenhouse emission

New generation treatment processes

- Resource recovery
- Small environmental footprint
- Cost-effective

Objective of this study



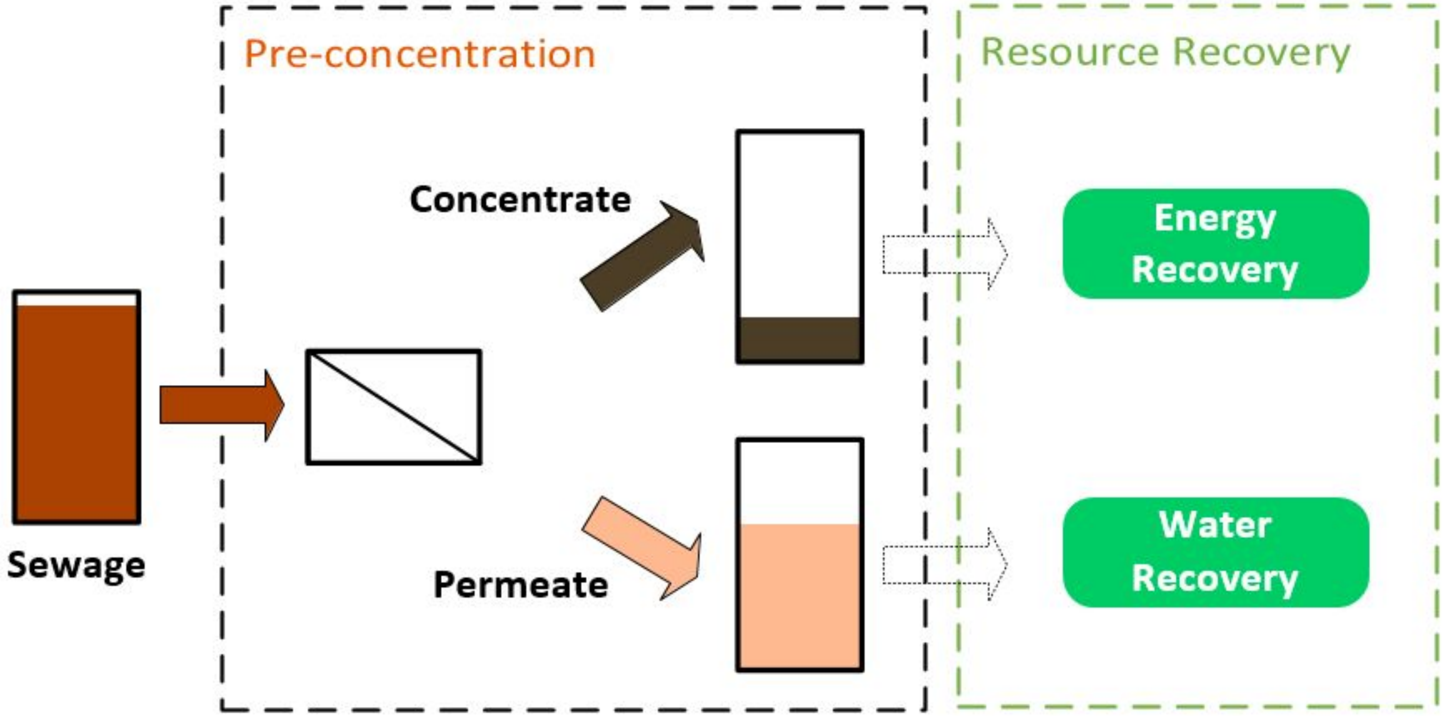
Direct ceramic membrane filtration (DCMF)

Direct membrane filtration

- simplicity of operation
- low net energy requirement
- high treated water quality
- high water recovery rate

Ceramic membrane

- Chemical and mechanical resistance
- High filtration flux
- Low fouling behavior



The characteristics of feed wastewater

Primary treated municipal wastewater

Kayseri Municipal Wastewater Treatment Plant

Conventional activated sludge process

Parameters	Raw Wastewater
pH	7.8±0.2
Conductivity (µS/cm)	2024±44
Turbidity (NTU)	194±5
COD (mg/L)	371±24
SO_4^{2-} (mg/L)	113±12
PO_4^{3-} (mg/L)	8.8±0.1
Cl^- (mg/L)	283.1±2.4
TSS (mg/L)	240±14

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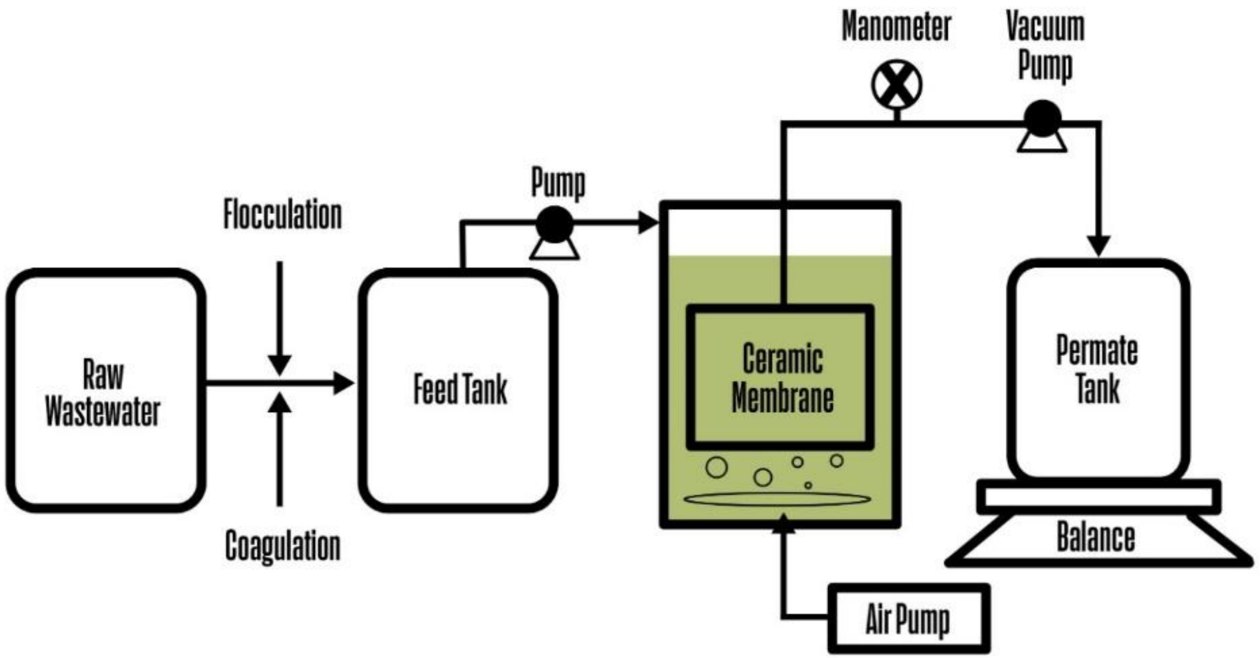
Experimental Set-up



Jar Test results for PAM

PAM dosage (mg/L)	pH	Conductivity (μS/cm)	COD (mg/L)	TSS (mg/L)	Turbidity (NTU)	NO_3^- (mg/L)	Cl^- (mg/L)	PO_4^{3-} (mg/L)
0.0	7.1±0.1	2025±21	347.0±7.1	55.0±35.4	100.0±1.4	ND	269.8±1.9	17.3±0.1
0.5	7.2±0.0	2015±7	368.9±11.5	60.0±14.1	122.5±19.1	1.3±0.1	284.6±0.8	8.1±0.1
1.0	7.2±0.0	2010±0	352.0±14.1	55.0±21.2	104.1±11.2	1.2±0.0	277.1±1.4	7.5±0.1
1.5	7.2±0.0	2000±0	329.5±1.8	20.0±0.0	97.4±3.3	1.2±0.0	282.7±0.8	7.8±0.1
2.0	7.1±0.1	1992±5	329.5±8.8	30.0±0.0	98.1±2.8	1.0±0.0	144.6±0.6	3.5±0.0
2.5	7.2±0.2	2000±0	330.8±15.9	25.0±7.1	95.9±2.4	1.3±0.3	280.1±2.4	7.7±0.1
3.0	7.2±0.0	2000±0	282.6±2.7	155.0±35.4	86.1±5.4	1.3±0.2	277.6±0.7	6.3±1.1
4.0	7.2±0.0	1997±1	282.0±8.8	120.0±42.4	89.4±1.1	ND	279.9±1.5	6.2±0.0
5.0	7.2±0.1	1997±1	267.0±0.0	70.0±42.4	76.1±1.1	ND	281.2±4.3	5.6±0.2

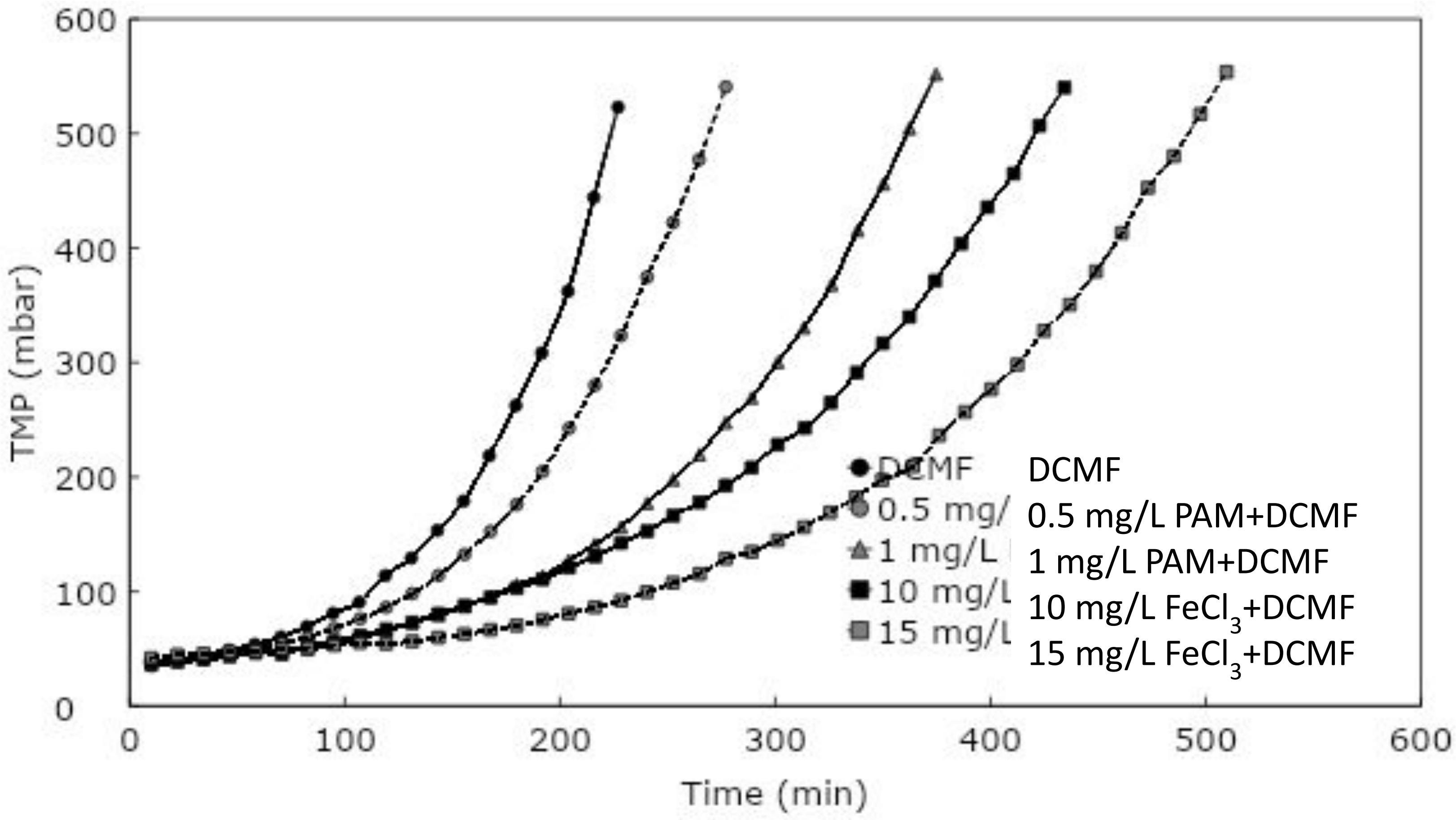
Jar Test results for $FeCl_3$

$FeCl_3$ dosage (mg/L)	pH	Conductivity (µS/cm)	COD (mg/L)	TSS (mg/L)	Turbidity (NTU)	NO_3^- (mg/L)	Cl^- (mg/L)	PO_4^{3-} (mg/L)
0.0	7.1±0.1	2025±21	347.0±7.1	55.0±35.4	100.0±1.4	ND	269.8±1.9	17.3±0.1
5	7.2±0.0	2002±12	321.4±29.2	55.0±7.1	75.4±1.8	ND	298.2±1.6	4.8±0.0
10	7.1±0.1	1997±3	275.1±27.4	60.0±0.0	63.3±1.7	ND	300.6±0.6	2.5±0.0
15	7.2±0.0	1997±4	258.9±13.3	60.0±56.6	55.9±4.0	ND	302.1±2.9	1.6±0.0
20	7.1±0.0	2010±0	258.9±15.0	40.0±28.3	52.1±0.9	ND	305.1±3.6	1.8±0.0
25	7.0±0.0	2010±14	254.5±12.4	35.0±7.1	41.9±0.1	ND	314.2±3.1	1.8±0.1
30	7.0±0.0	2010±0	207.6±2.7	60.0±56.6	40.4±0.4	ND	319.5±0.7	1.8±0.0
40	6.9±0.0	2020±0	271.38±0.9	60.0±14.1	40.5±0.4	1.2±0.0	338.8±9.2	1.8±0.3
50	6.9±0.0	2010±0	238.3±5.3	85.0±21.2	34.6±1.8	1.3±0.0	347.0±9.6	1.9±0.5

Jar Test results for $FeCl_3$+PAM

$FeCl_3$ +PAM dosage (mg/L)	pH	Conductivity (µS/cm)	COD (mg/L)	TSS (mg/L)	Turbidity (NTU)	NO_3^- (mg/L)	Cl^- (mg/L)	PO_4^{3-} (mg/L)
0.5 + 5	7.3±0.1	2003±0	213.8±8.0	200.0±14.1	25.8±0.3	1.3±0.0	289.7±0.9	5.0±0.2
0.5 + 10	7.5±0.3	2002±0	201.4±9.7	155.0±49.5	24.9±0.9	1.4±0.1	294.6±2.1	3.1±0.0
0.5 + 15	7.5±0.2	2004±1	179.5±0.0	215.0±49.5	22.5±0.2	1.4±0.3	302.3±4.8	1.5±0.0
1.0 + 5	7.3±0.1	2002±0	215.8±15.9	115.0±7.1	27.9±0.4	1.4±0.1	287.5±2.1	4.7±0.1
1.0 + 10	7.3±0.1	2003±1	185.1±13.3	95.0±7.1	20.9±1.1	1.6±0.0	300.6±2.2	3.2±0.0
1.0 + 15	7.2±0.1	2004±2	164.5±5.3	80.0±14.1	18.7±0.0	1.5±0.4	297.1±1.1	1.6±0.0

TMP profile for filtration tests



Permeate characterstics for DCMF tests

DCMF tests	pH	Conductivity (µS/cm)	Turbidity (NTU)	COD (mg/L)	Cl^- (mg/L)	PO_4^{3-} (mg/L)	SO_4^{2-} (mg/L)
DCMF	8.1±0.1	1978±10	3.4±0.2	168±37	274±0	7.8±2.1	139±54
0.5 mg/L PAM+DCMF	8.1±0.1	1934±23	2.7±1.3	113±20	271±11	8.5±0.5	88±5
1.0 mg/L PAM+DCMF	8.5±0.1	1937±27	3.2±0.8	111±3	272±12	7.6±1.5	99±7
10 mg/L $FeCl_3$+DCMF	8.3±0.1	1978±21	2.7±1.7	126±23	296±1	4.3±0.6	92±3
15 mg/L $FeCl_3$+DCMF	8.4±0.2	1966±6	3.8±1.4	117±51	296±3	2.3±0.1	99±6

Conclusions

- Pre-coagulation and/or flocculation ☐ control of TMP rising in DCMF operations
- 1 mg/L PAM and 15 mg/L $FeCl_3$ were critical for TSS, COD, and turbidity removal efficiency
- 10 and 15 mg/L $FeCl_3$+DCMF ☐ the best TMP behavior
- 1.0 mg/L PAM+DCMF and 15 mg/L $FeCl_3$+DCMF ☐ the greatest COD and PO_4^{3-} removal
- PO_4^{3-} content in irrigation water ☐ advantage
- $FeCl_3$ ☐ the rising of Cl^- concentration
- Salinity was the major problem ☐ additional membrane filtration such as nanofiltration

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