Feasibility Study on Innovative Hybrid Wastewater Treatment Design to Achieve Carbon and Energy Neutrality

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Background

v Aerobic digestion (AD) has been commonly used in wastewater treatment, however, it consumes much electricity. In 2019, 292 Million kWh was consumed in H.K. for wastewater treatment processes.

v Treatment by AD process generating methane can be used for electricity generation. However, AD process is slow due to low levels of chemical oxygen demand (COD), while residual nutrients NH_4^+ (N) & PO_4^{3-} (P) after the AD process should be further removed.

v Forward osmosis (FO) can be adopted to pre-concentrate COD level to achieve higher performance in the AD process.

Objectives

v To perform FO pre-concentration of synthetic domestic wastewater using 28‰ NaCl (seawater) as draw solution.

v To determine the water flux (LMH) and volume concentration factor achieved in the FO process.

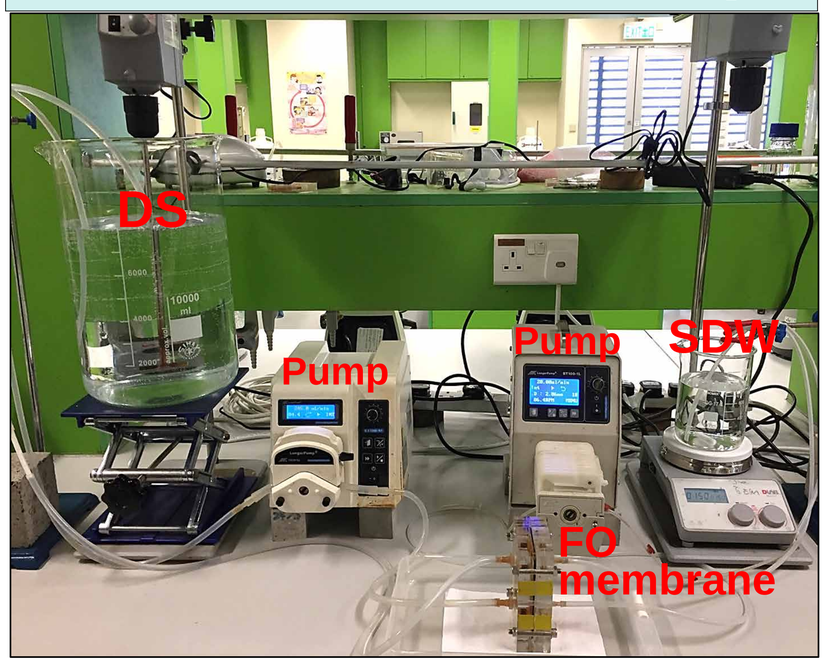
v To investigate the inhibitory effect of residual COD (after AD process) towards microalgae growth.

Materials

v For FO: synthetic domestic wastewater (SDW: 800 mL), peristaltic low pressure pump for SDW & draw solution (DS: 8L) flows, FO setup with membrane surface area: 3 cm x 7 cm, conductivity meter (for osmotic pressure monitoring).

v For microalgae growth: *Tetraselmis* sp., incubating shaker with light-dark cycle, Guillard medium, spectrophotometer (for cell density measurement).

Forward osmosis setup



Method

v SDW was pre-concentrated by FO using 28‰ NaCl (seawater) as DS under low pressure condition.

v The volume concentration factor of SDW by FO was determined, water flux (Liter per m^2 h)(LMH) from SDW and changes in conductivity in both DS and SDW were also measured.

v Effect of concentrated SDW towards microalgae growth was investigated to determine potential inhibitory effects. Besides, the effect of residual COD level towards microalgae growth was also investigated during 4 weeks of incubation.

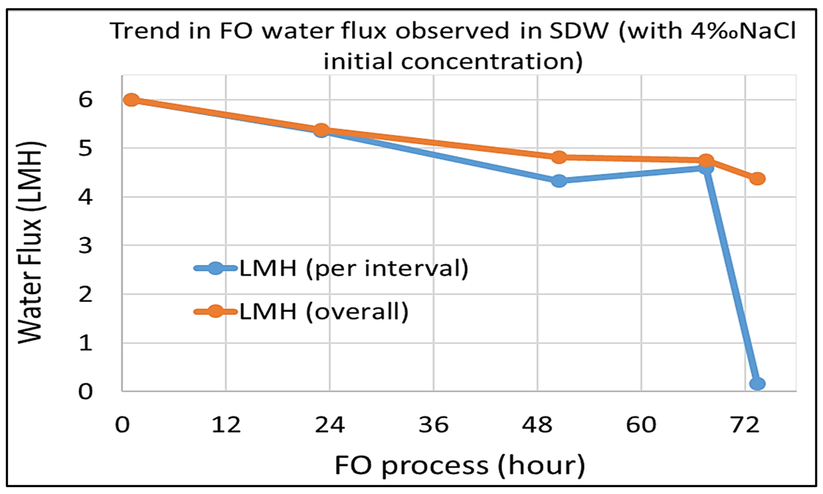
Results: FO pre-concentration

v <u>SDW prepared in freshwater</u>:

After 19 h of FO process:
Water flux: 6.96 LMH
FO volume concentration factor: 1.54X

v <u>SDW prepared in 4‰ NaCl:</u>

After 23 h of FO process:
Water flux: 5.38 LMH
FO volume concentration factor: 1.48X



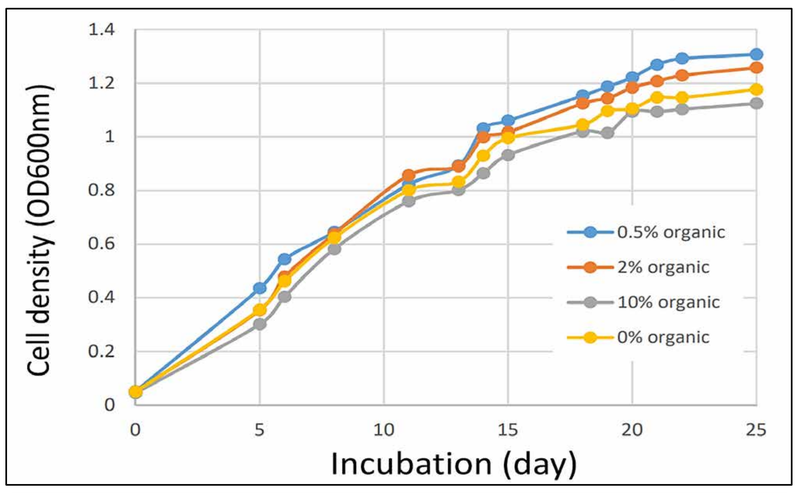
Results: microalgae growth

v FO in concentrated SDW would be treated by AD resulted in 90-98% COD removal, however, high residual contents of salts & nutrients N & P should be subjected for post-treatment.

v Results showed that normal growth of marine microalgae, *Tetraselmis* sp. can be observed using culture medium mixed with FO concentrated SDW (salts, N & P) and natural seawater.

v In the presence of 0.5-2% COD (remained after AD), it can stimulate the cells growth, but inhibition was observed at high COD level i.e.10%.

X4:0.5%; X5:2%; X6:10%; X7:0% organics in mixture of FO concentrated SDW + seawater at Day 25



Conclusion

v FO can be applied to pre-concentrate SDW (4‰ initial NaCl) with volume concentration factor up to 6.45X by using seawater (28‰ NaCl) as DS.

v High LMH (>4) was achieved until osmotic pressure difference between DS and SDW has reached equilibrium.

v Normal growth pattern of microalgae was observed in the presence of FO in concentrated SDW (with high salts & nutrients content). Low level of residual organics (0.5-2%) enhanced micro-algae growth. Promising results show that using FO and microalgae as pre- & post-treatment can be integrated with the AD treatment process.

Acknowledgment

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