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Institute of Environmental Engineering and Management

A NOVEL THERMOPHILIC ANAEROBIC MEMBRANE DISTILLATION BIOREACTOR FOR METHANE RECOVERY AND WASTEWATER RECLAMATION



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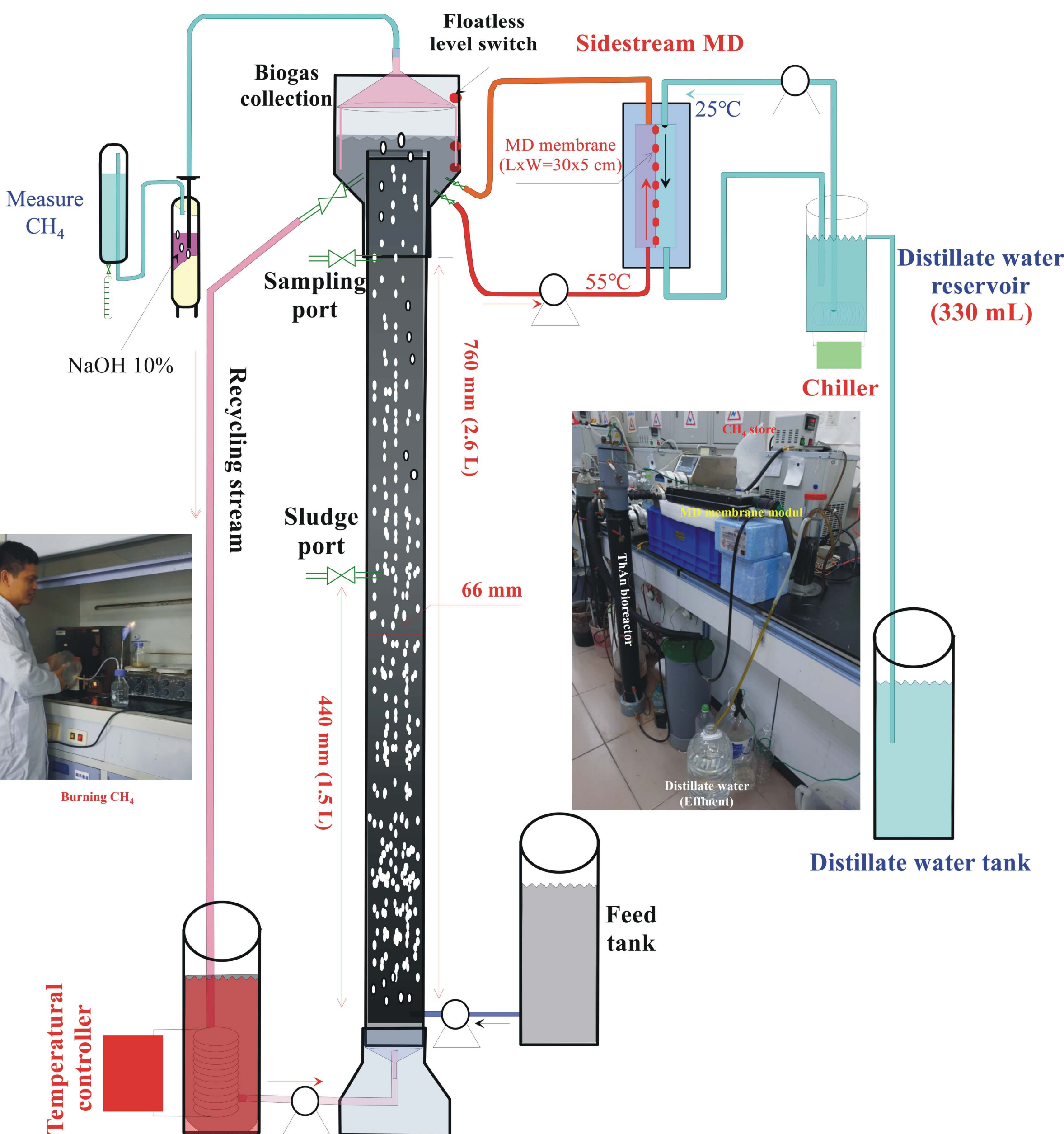
RESEARCH TOPIC

With the most devastating impact in the global water crisis, water reclamation at wastewater treatment plants can be used as alternative water resources. A thermophilic anaerobic (ThAn) process has certain advantages: rapid biodegradation, shorter retention times, destroyed pathogens, and methane production. However, the remaining disadvantages are low-quality and high-temperature of effluent. Integrating membrane distillation (MD) with ThAn is a novelty solution capable of overcoming ThAn's disadvantages and producing high-quality clean water comparable to the water production from the reverse osmosis membrane appropriate for water reuse.

RESEARCH FOCUS

- Evaluate the stability of the ThAn-MD system, methane recovery, and wastewater reclamation at various OLRs.
- Evaluate the effect of the MD membrane in self-buffering to maintain the pH for ThAn bioreactor.
- Evaluate the ability of the ThAn-MD in the treatment of high strength real wastewater (tapioca bubble cooking wastewater) for methane recovery and wastewater reclamation.
- Controlling the influent of ThAn bioreactor for the improvement of distillation water quality and the reduction of salt accumulation in the ThAn bioreactor and chemical supplement in operation.

RESEARCH RESULTS



Flow diagram of a lab-scale ThAn-MD bioreactor

- The organic loading rate of 13 to 16 kg COD/m³/day was found to be optimum for ThAn bioreactor. The COD removal rate was higher than 99.4%, and the CH₄ yield was 332 NmL/g-COD_{removed}.
- The MD membrane worked as the final barrier to maintain the consistent production of high-quality water with a TOC ≤ 1.7 mg/L, a PO₄³⁻-P non-detection, and EC of less than 120 μS/cm.
- The MD made self-buffering capacity for ThAn bioreactor, which resulted in a zero-alkalinity additional requirement for ThAn even though the feed's alkalinity was zero.

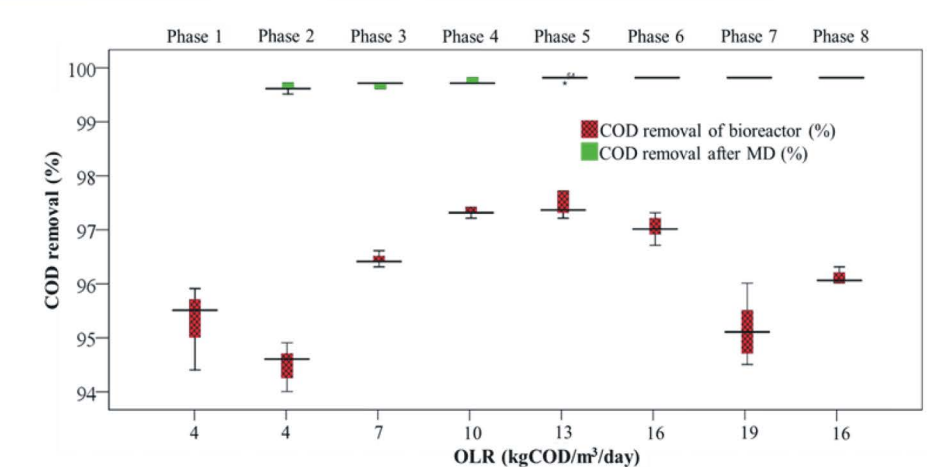


Figure: Effect of OLR on COD removal of the ThAn-MD system

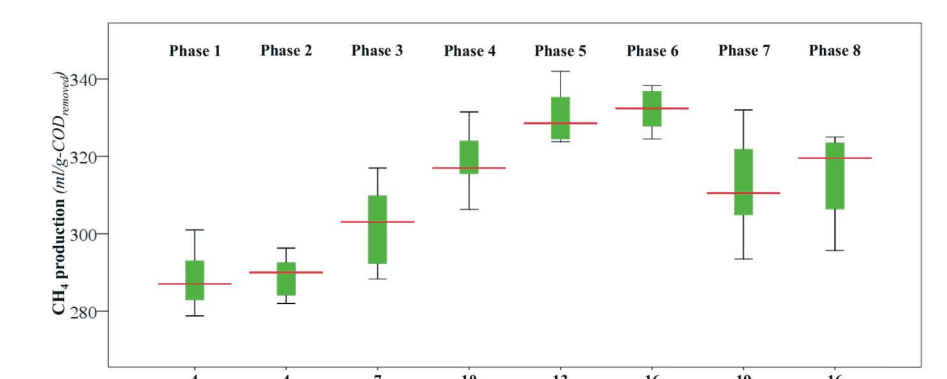


Figure: Effect of OLRs on methane yield of the ThAn-MD system

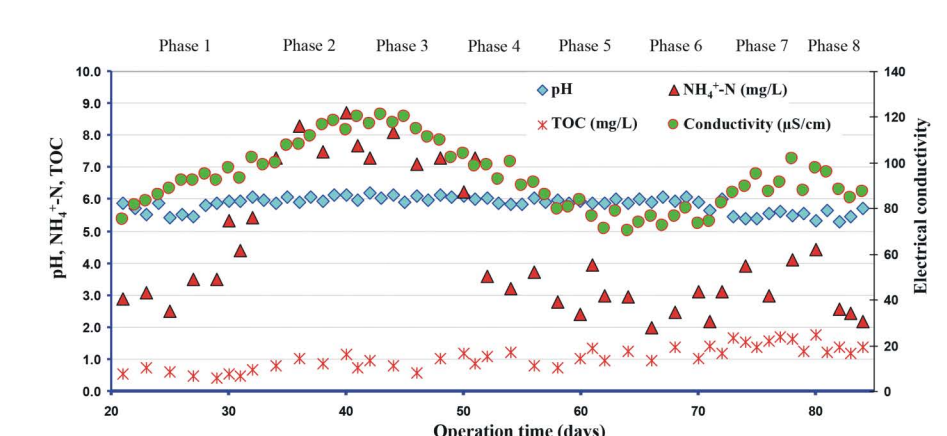


Figure: The various distillate water quality of the ThAn-MD system

SELECTED JOURNAL PUBLICATIONS

- Chinh Cong Duong, Shiao-Shing Chen, Huy Quang Le, Hau-Ming Chang, Nguyen Cong Nguyen, and Dan Thanh Ngoc Cao. "A novel self-buffering membrane distillation-based thermophilic anaerobic bioreactor." *Environmental Technology & Innovation* 19 (2020): 100993. <https://doi.org/10.1016/j.eti.2020.101077>.
- Chinh Cong Duong, Shiao-Shing Chen, Huy Quang Le, Hau-Ming Chang, Nguyen Cong Nguyen, Dan Thanh Ngoc Cao, and I. Chieh Chien. "A Novel Thermophilic Anaerobic Granular Sludge Membrane Distillation Bioreactor for Wastewater Reclamation." *Environmental Science and Pollution Research* (2020). <https://doi.org/10.1007/s11356-020-09987-4>.
- Nguyen, Nguyen Cong, Hung Cong Duong, Hau Thi Nguyen, Shiao-Shing Chen, Huy Quang Le, Huu Hao Ngo, Wenshan Guo, Chinh Cong Duong, et al. "Forward Osmosis-Membrane Distillation Hybrid System for Desalination Using Mixed Trivalent Draw Solution." *Journal of Membrane Science* 603 (2020): 118029. <https://doi.org/10.1016/j.memsci.2020.118029>.