NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE | Nanyang Environment and Water Research Institute

AN IRON-CYCLING DRIVEN ANAEROBIC AMMONIUM OXIDATION PROCESS THE MICROAEROBIC GRANULAR SLUDGE (MGS)

Abstract

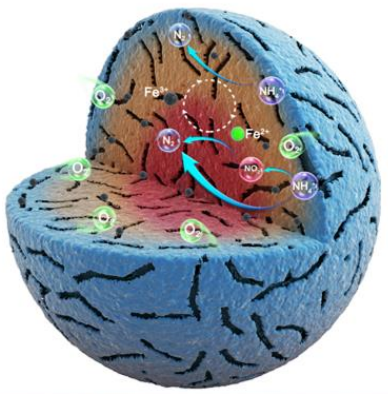
Cutting-edge technologies are key enablers of Singapore's sustainable water management and sanitation. This project addresses our needs for a weather-resilient urban water management, targeting especially at our industrial and municipal wastewaters and finding solutions to strengthen our current capacity to meet future demands for wastewater treatment and resource recovery.

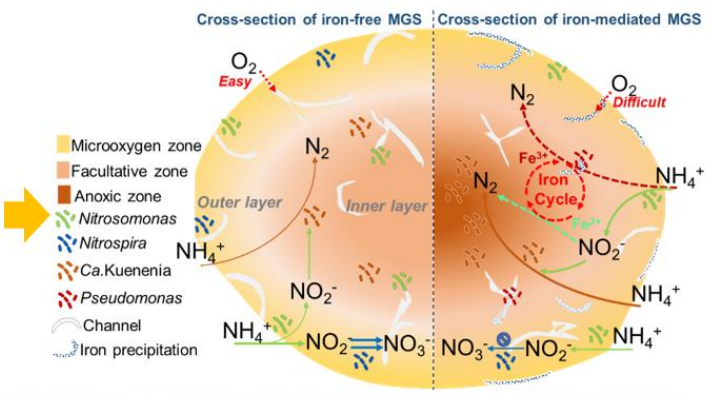
Our strategy amalgamates state-of-the-art membrane technology with advanced biological processes – anaerobic ammonia oxidizing (Anammox) process coupled with Fe^{3+} reduction (Feammox) and membrane bioreactor (MBR) – to realize more holistic, cost-competitive and energy-efficient wastewater treatment systems. To unlock this potential, the core technology is centered on the development of novel chemically-resistant membranes, which will (1) facilitate proof-of-concept of a new Feammox process for industrial wastewaters, and (2) enable high technological readiness level (TRL) demonstration of an enhanced MBR technology for municipal wastewater reclamation. Specifically, our research focus and objectives are as follows:

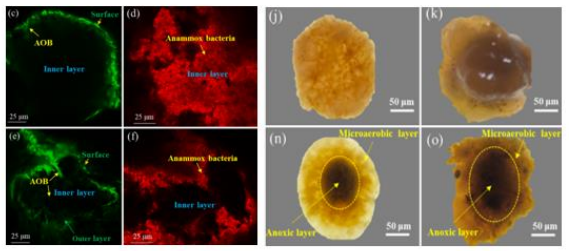
(1) To develop an integrated biotechnology-membrane system for high strength industrial and inhibitory wastewater treatment and resources recovery for reuse. Target liquid streams could be from waste management and petrochemical industries, which can include thermal hydrolysis anaerobic digestion (THP-AD) centrate, chicken farm AD centrate, sludge and food waste co-digestion (Co-D) centrate, or other types of low carbon to nitrogen (C/N) ratio wastewater, where ammonia concentration is very high, but biodegradation chemical oxygen demand (COD) concentration is low or when organic compounds are recalcitrant/inhibitory. Working on these liquid streams also supports Singapore's endeavor on finding sustainable solutions for drinking water sludge reuse and resources recovery.

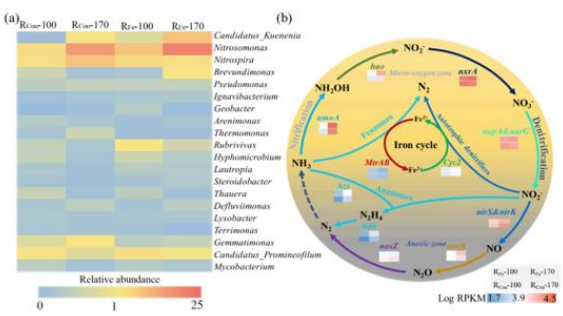
(2) On the other hand, to develop an enhanced MBR system to reclaim water from municipal wastewater, with detailed objectives including: (a) Design and fabricate novel high-flux and pH-stable polymeric composite NF membranes with low operating pressure of ~2 bar; (b) Demonstrate scalability of selected NF membrane for production of up to 4-inch diameter module (at TRL 6); (c) Integrate the scaled-up NF membrane module with biological MBR process to achieve ≥90% overall recovery of reclaimed water by a downstream reverse osmosis (RO) process

AUTOTROPHIC NITROGEN REMOVAL









Granule-based partial nitritation and anaerobic ammonium oxidation (PN/A) is an energy-efficient approach for treating ammonia wastewater. When treating low-strength ammonia wastewater, the stable synergy between PN and anammox is however difficult to establish. Here, we proposed, the PN/A granular sludge formed by a micro-oxygen-driven iron redox cycle with continuous aeration as a novel strategy to achieve stable and efficient nitrogen removal

PERFORMANCE AND MECHANISMS

- Due to the formation of the MGS, the bio(chemistry)-driven iron cycle could be formed with the support of anaerobic ammonium oxidation coupled to Feammox
- Both ammonia-oxidizing bacteria and generated Fe^{2+} could scavenge the oxygen as a defensive shield for oxygen-sensitive anammox bacteria in the MGS
- The spatiotemporal assembly of functional microorganisms in the MGS for the realization of stable PN/A could be achieved with the support of the iron redox cycle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