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Energy-efficient, environmentally-friendly secondary wastewater treatment using a novel membrane-aerated biofilm reactor (MABR) design

Stanford researchers have developed a strategy for secondary wastewater treatment using a membrane-aerated biofilm reactor (MABR) design that enables the simultaneous removal of pollutants and recovery of potent greenhouse gas (N2O) emissions.

Conventional domestic wastewater treatment is based on aerobic processes, resulting in a large carbon footprint due to high energy consumption and N2O emissions during biological nitrogen removal. A recent systems-level analysis emphasizes that carbon footprint due to N2O emissions is more significant than the footprint resulting from energy use. Anaerobic secondary treatment has been proposed to enable energy-efficient removal of organic matter but will have similar N2O emissions in a post-treatment for biological nitrogen removal. A method for N2O emission control is clearly needed.

To address this, Stanford researchers developed a novel strategy where a membrane-aerated bioreactor (MABR) is incorporated for both aerobic secondary treatment and tertiary treatment after anaerobic secondary treatment to recover N2O produced during biological nitrogen treatment. Biofilm attached to gas permeable membrane surfaces in the MABR effectively remove biodegradable compounds from the aqueous phase, enabling low energy consumption. The biofilms also create a driving force for counter diffusion of N2O from the membrane-attached biofilm into the lumen of the membranes. This driving force increases N2O

concentration within the lumen, facilitating recovery of N2O-enriched off-gas and minimization in carbon footprint. The N2O-enriched off-gas can be used for energy production in a biogas engine or in a system that recovers combined heat and power (CHP).

Stage of Development
Pilot: treatment of 4,320 gallons of secondary effluent per day at the Silicon Valley Clean Water wastewater treatment facility, enabling recovery of > 99% N2O with a low energy requirement (0.06 kWh/m^3)

Applications

- Wastewater treatment

Advantages

- Simple, single-step process
- Enables reduction in > 90% greenhouse gas emissions
- Low energy requirement due to highly efficient aeration
- Improved versatility and reliability of wastewater treatment

Patents

- Published Application: WO2024081433

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