Microalgae modeling in water resource recovery facilities - Toward a consensus

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Toward a consensus

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Motivation

Microalgal resource recovery systems could significantly advance nutrient recovery from wastewater by achieving efficient concentrations of nitrogen and phosphorus below the current limit of technology for nutrient recovery. The advancement of algal treatment processes and their broad adoption, however, is contingent upon the ability to reliably and accurately simulate full-scale performance in response to reactor and process design, influent composition, and environmental conditions. To advance the broader implementation of algal process models by practitioners, it is critical to establish a unified modeling framework that is capable of accounting for relevant process and environmental conditions while simultaneously avoiding unnecessary complexity.

Figure 1. Full-scale microalgal wastewater treatment installations; (a) ECOGUNA ‘hanging garden’ design, (b) horizontal tubular reactor design courtesy of Clearas Water Recovery Inc.

1 Light

- Irradiance: photosynthesis-irradiance models commonly used include: Eilers and Peeters, Steele, and Platt and Jassby
- Photosynthesis-irradiance models should balance accuracy and complexity

2 Metabolism and Growth

- Monod growth model: external substrate uptake
- Droop model: internal nutrient stores
- Andrews/Haldane growth model: high substrate uptake, inhibition

3 Nutrient Uptake

- When algae are exposed to fluctuating nutrient concentrations, Droop is better at simulating the lag between uptake and growth due to replenishment of internal nutrient stores
- Monod immediate growth – growth stalled when nutrients fully consumed
- Droop lagged growth – growth continues after nutrients fully consumed

4 Carbon Storage

- Carbon storage as a function of biomass growth
- Lipids stored more quickly
- Carbohydrates stored and mobilized more slowly
- These other processes are often non-parallel with algal and cyanobacterial growth, but their impacts are often non-negligible; thoughtful consideration should be given when determining whether to include these processes

5 Additional Processes

- Gas Transfer
- Respiration
- pH

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Additional Processes. These processes should be considered if they could impact growth rates.