Underlying Microbial Bioprocesses of Biological Nutrient Removal

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Introduction

- Fundamental and applied research in microbiology and engineering with various methods and scales has advanced our understanding of key microbial bioprocesses for biological nutrient removal (BNR)
- There is a need to comprehensively summarize BNR bioprocess research to facilitate understanding across disciplines and improve implementation, which can take decades in the wastewater industry[1]

Methods

- Systematically reviewed wastewater treatment processes out of a total body of 285 articles by recording qualitative and quantitative attributes using a standardized data collection template
- One to five articles reviewed per individual process chosen based on citation frequency, specificity to wastewater treatment, and advancement of technology to larger scales
- Developed categories for comparing technology development and implementation

Discussion & Future Work

- There is a lack of consistency in reported qualitative metrics such as species removed and lack of metrics that support full-scale implementation such as cost or emissions for nutrient removal
- TRL is a viable metric for reporting technology development in the wastewater field
- Proposing guidelines for quantitative and qualitative metric reporting can increase consistency between fundamental and applied research across disciplines

Results

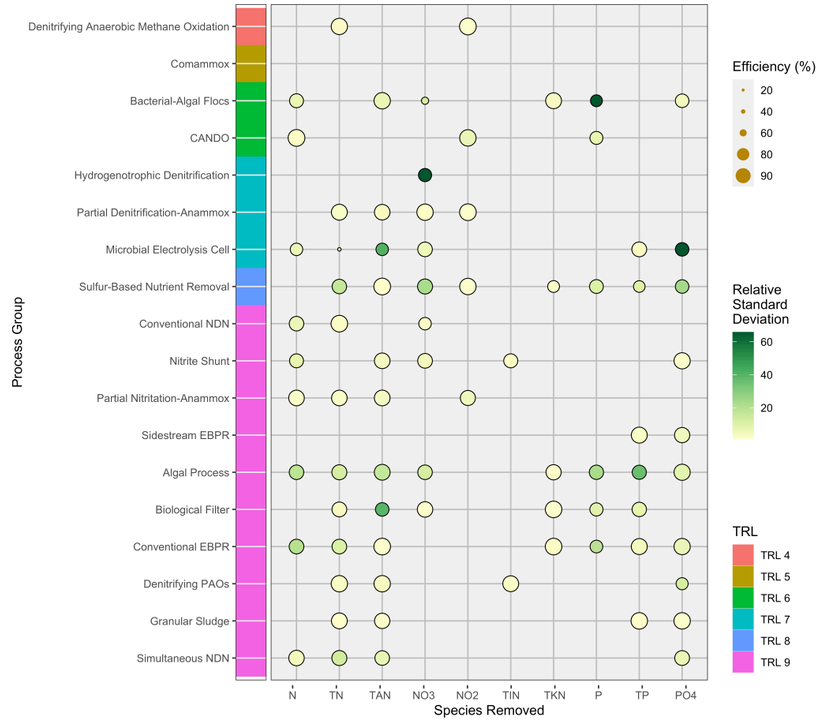
Table 1. Bioprocesses at work
Nutrient removal technologies can be classified by the type of bioprocess that underlies nutrient removal. Based on the literature reviewed, the general removal mechanisms are assimilation and transformation.

Mechanism	Description	Processes
Assimilation	Nutrients are primarily incorporated into biomass, requiring intentional biomass removal to achieve nutrient removal	Algal processes, Conventional enhanced biological phosphorus removal (EBPR), Sidestream EBPR
Transformation	Nutrients are primarily transformed into inert forms or recoverable products through microbially mediated reactions	Conventional nitrification-denitrification (NDN), Comammox, Coupled Aerobic-Anoxic Nitrous Decomposition Operation (CANDO), Denitrifying anaerobic methane oxidation, Hydrogenotrophic denitrification, Microbial electrolysis cell, Nitrite shunt, Partial denitrification-anammox (PdNA), Partial nitritation-anammox (PNA), Sulfur-based nutrient removal
Hybrid	Nutrients are removed through both assimilation and transformation,	Bacterial-algal flocs, Biological filters, Denitrifying phosphorus accumulating organisms (PAOs), Granular sludge

Table 2. TRL levels and descriptions
TRL – Technology Readiness Level: Metric used to describe technology development[2,3]. Processes were labeled by the highest TRL identified in literature. TRLs 1-3 (not shown) are lab-scale studies that identify underlying principles and validate predictions about microbial process.

TRL	Description adapted from [2] and [3]
TRL 4	Laboratory-scale studies that demonstrate the function of the technology after components have been assembled as a system, using synthetic wastewater as the influent.
TRL 5	Laboratory-scale studies that test the technology in a simulated operational environment, using real wastewater as the influent.
TRL 6	Pilot-scale studies that test the technology in a simulated operational environment.
TRL 7	Pilot-scale studies that test the technology in an operational environment.
TRL 8	Full-scale, plant-wide studies that test the technology in an operational environment.
TRL 9	Full-scale implementation of technology in operational environment for “long-term” use.

Figure 1. Removal efficiency and TRL of BNR process groups
Removal efficiencies, a key metric for identifying the effectiveness and viability of a nutrient removal process, were aggregated from each paper.



References & Acknowledgements

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