REQUEST FOR PROPOSALS (RFP)

Unlocking the Advantages of Internally Stored Carbon for Nutrient Removal (5245)

Date Posted
Monday, September 11, 2023

Due Date
Proposals must be received by 3:00 pm Mountain Time on Tuesday, November 21, 2023.

WRF Project Contact
Stephanie Fevig, sfevig@waterrf.org

Project Sponsors
This project is funded by The Water Research Foundation (WRF) as part of WRF's Research Priority Program.

Project Objectives
- Identify knowledge gaps and advance fundamental scientific knowledge related to biological nutrient removal (BNR) driven by internally stored carbon
- Identify and quantify benefits of achieving BNR via internally stored carbon, including comparisons of performance in systems with enrichment of carbon-storing biomass versus those without carbon-storing biomass enrichment
- Synthesize findings into an application guidance document for design and operations

Budget
Applicants may request up to $250,000 in WRF funds for this project.

Background and Project Rationale
Internal carbon storage is central to several BNR phenomena, including enhanced biological phosphorus removal (EBPR), denitrification, and activated sludge densification. Understanding how to promote internal carbon storage utilizing influent wastewater to facilitate more efficient BNR can help offset costs and improve treatment resilience.

The role of internally stored carbon is relatively well understood for EBPR; however, the conditions that promote the excess storage of carbon and the subsequent use for nitrogen (N) removal and densification are not well understood. There is limited understanding of the impact of internal carbon sources and other carbon sources on anoxic phosphorus (P) uptake via electron acceptors (e.g., nitrate and nitrite) and on partial denitrification kinetics.

The following are important questions and topics to be considered under this project:

- What are the key microorganisms and their role in metabolic conversions, kinetics, and substrates? How does carbon feed type (e.g., primary influent or effluent, primary sludge fermentate, return activated sludge (RAS)/mixed liquor suspended solids (MLSS) fermentate) affect microorganism genera and the changes observed in their species with the choice of the sludge and the volatile fatty acid (VFA) extraction technique?
- Identification of reliable measurement and tools, operational conditions, and challenges (e.g., competition and impact with external chemical amendments) with internally stored carbon used for a variety of BNR process configurations.
- What are the internal carbon storage quantification methods, their advantages and disadvantages, and practical utility for operations monitoring?
- Does stored carbon-based denitrification necessarily result in nitrite accumulation? Address potential for nitrite and free nitrous acid accumulation and nitrous oxide emissions. Are certain carbon storage driven BNR configurations and/or operating conditions more favorable for limiting nitrous oxide emissions?
- Conflicting information exists on the type of carbon sources that favor maximum VFA production to increase simultaneous denitrification and P removal. What are the various carbon sources and their mechanisms to favor simultaneous denitrification and P removal?
- What is the potential for precipitate formation (e.g., struvite) within biomass and full-scale implications?
- Are there challenges or limitations to anoxic P uptake due to nitrate and nitrite now being more prominent electron acceptors outside of aerobic zones and/or aerobic portions of floc/biofilms?
- Is there an optimal balance between providing sufficient solids retention time (SRT) for complete degradation of internal carbon reserves (thus maximizing internal carbon for nutrient removal) versus reactor sizing to provide such an SRT?
- Are there specific carbon loading levels or carbon types/fractions that favor combined N and P removal via internal carbon storage? Information on optimal C/N and C/P ratios yield more clarity on the topic.
- Can low total N (TN) limits be reliably achieved by leveraging internally stored carbon for post-anoxic denitrification? What influent C/N ratio(s) are required to reliably achieve low TN limits? Are there differences in facility design, sizing, etc. for approaches based on internal carbon storage and utilization versus using external carbon sources?
- What are the options to address and resolve the challenges associated with the release of soluble organic P and ammonium-N?
- Does the absence/presence of a biofilm-like densified activated sludge morphology affect characteristics of treatment systems enriched with carbon-storing biomass? Example characteristics that may be affected include treatment performance, optimal operating conditions, apparent kinetics, and N fluxes/fate.
- Are established model structures and commercial modeling platforms appropriate for predictive simulations of treatment systems enriched with carbon-storing biomass in the absence of the presence of such biomass for calibration purposes? What models or modifications are needed to accommodate such simulations (if practical)? What is the

range of certainty/uncertainty and how can that be addressed in design and operation?

Research Approach

This RFP is intentionally flexible in the research approach to encourage creativity and originality from proposers. Proposers should describe how they will conduct the research to achieve the objectives listed below. The research approach should be structured to address the key objectives.

- **Objective 1 – Advance Fundamental Knowledge**
  - Identify knowledge gaps and gain fundamental scientific knowledge related to BNR driven by internally stored carbon. Topics of interest include microbiology, metabolic pathways, kinetics, nutrient conversion pathways, nutrient fluxes, and mass balances. A particular emphasis on N conversions and anoxic P uptake is anticipated. It is anticipated that a combination of bench/pilot studies, full-scale case studies, and process modeling may be used to advance fundamental knowledge.
- **Objective 2 – Benefits Quantification**
  - Identify and quantify benefits of achieving BNR via internally stored carbon, including comparisons of systems with enrichment of carbon-storing biomass to those without such enrichment. Comparisons should consider nutrient removal performance, costs, greenhouse gas emissions, and other key performance indicators. Identify potential downsides, limitations, or drawbacks of a particular emphasis on carbon-storing biomass enrichment for BNR.
- **Objective 3 – Application Guidance**
  - Synthesize findings into an application guidance document for design and operations that promote long-term carbon storage and utilization for effective BNR. Topics to be addressed should include system configurations and sizing, cost considerations, treatment performance, wastewater characteristics, environmental and operating variables, control strategies, resource recovery opportunities, solids handling, and other relevant conditions and considerations. Address the need for up-scaling where relevant

Expected Deliverables

Deliverables should include, but are not limited to:

- Research report (must use WRF's Research Report Template, which can be found at https://www.waterrf.org/project-report-guidelines#research-report-template) including literature review, new work under the study, case studies, etc. Report should include literature review of appropriate breadth to document state of knowledge and identify knowledge gaps.
- Guidance document focusing on applied design and operations.
- Workshops:
  - One kickoff workshop with the WRF project advisory committee (PAC) (virtual platform acceptable). The PAC is a volunteer expert technical review committee managed by WRF.
  - One in-person progress workshop with WRF PAC.

- One workshop with the WRF PAC when the project is near substantial completion (virtual platform acceptable).

Communication Plan
Please review WRF's *Project Deliverable Guidelines* for information on preparing a communication plan. The guidelines are available at https://www.waterrf.org/project-report-guidelines#project-deliverable-guidelines. Conference presentations, webcasts, peer-reviewed publication submissions, and other forms of project information dissemination are typically encouraged.

Project Duration
The anticipated period of performance for this project is 24-36 months from the contract start date.

References and Resources
The following list includes examples of research reports, tools, and other resources that may be helpful to proposers. It is not intended to be comprehensive, nor is it a required list for consideration. Links to project pages are provided below. Please contact Stephanie Fevig (sfevig@waterrf.org) for project deliverables and draft reports, if available.

- Downing, L. Forthcoming. *Practices to Enhance Internal Fermentation of Side-Stream Secondary Sludge and Mixed Liquor Suspended Solids for Biological Phosphorus Removal.* Project 4975. Denver, CO: The Water Research Foundation. https://www.waterrf.org/research/projects/practices-enhance-internal-fermentation-side-stream-secondary-sludge-and-mixed
- Jimenez, J. Forthcoming. *Advancing Low-Energy Biological Nitrogen and* Phosphorus *Removal.* Project 5083. Denver, CO: The Water Research Foundation. https://www.waterrf.org/research/projects/advancing-low-energy-biological-nitrogen-and-phosphorus-removal
- Regmi P. Forthcoming. *Advancement of Densification to Implement and Achieve More Efficient BNR Processes: Granule Generation, Retention and Management.* Project 5130. Denver, CO: The Water Research Foundation. https://www.waterrf.org/research/projects/advancement-densification-implement-and-achieve-more-efficient-bnr-processes
- Regmi, P., M. Armenta, and K. Bauhs. 2023. *A State of Knowledge: Exploring the Densification Continuum*. Project 5130. Denver, CO: The Water Research Foundation. https://www.waterrf.org/research/projects/advancement-densification-implement-and-achieve-more-efficient-bnr-processes
- Regmi, P., M. Johnson, Jr., C. Nguyen, G. Wells, and A. Al-Omari. 2023. *Demonstration of Progressive Carbon Efficient Nitrogen with Biological Phosphorus Removal in a Conventional BNR Facility*. Project 5071. Denver, CO: The Water Research Foundation. https://www.waterrf.org/resource/demonstration-progressive-carbon-efficient-nitrogen-biological-phosphorus-removal-1

- WRF. 2023. *Advancing Anoxic Phosphorus Uptake for Highly Efficient Simultaneous Nitrogen and Phosphorus Removal*. RFP 5252. WRF.

Proposal Evaluation Criteria
The following criteria will be used to evaluate proposals:

- Understanding the Problem and Responsiveness to RFP (maximum 20 points)
- Technical and Scientific Merit (maximum 30 points)
- Qualifications, Capabilities, and Management (maximum 15 points)
- Communication Plan, Deliverables, and Applicability (maximum 20 points)
- Budget and Schedule (maximum 15 points)

PROPOSAL PREPARATION INSTRUCTIONS

Proposals submitted in response to this RFP must be prepared in accordance with WRF's *Guidelines for Research Priority Program Proposals*. The current version of these guidelines and the *Instructions for Budget Preparation* are available at https://www.waterrf.org/proposal-guidelines. The guidelines contain instructions for the technical aspects, financial statements, indirect costs, and administrative requirements that the applicant must follow when preparing a proposal.

Proposals that include the production of web- or software-based tools, such as websites, Excel spreadsheets, Access databases, etc., must follow the criteria outlined for web tools presented in the *Web Tool Criteria and Feasibility Study for The Water Research Foundation Project Deliverables* at https://www.waterrf.org/project-report-guidelines#webtool-criteria.

Eligibility to Submit Proposals
Proposals will be accepted from both U.S.-based and non-U.S.-based entities, including educational institutions, research organizations, governmental agencies, and consultants or other for-profit entities.

WRF's Board of Directors has established a Timeliness Policy that addresses researcher adherence to the project schedule. The policy can be reviewed at https://www.waterrf.org/policies. Researchers who are late on any ongoing WRF-sponsored studies without approved no-cost extensions are not eligible to be named participants in any proposals. Direct any questions about eligibility to the WRF project contact listed at the top of this RFP.

Administrative, Cost, and Audit Standards
WRF's research program standards for administrative, cost, and audit compliance are based upon, and comply with, Office of Management and Budget (OMB) Uniform Grants Guidance (UGG), 2 CFR Part 200 Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards, and 48 CFR 31.2 Contracts with Commercial Organizations. These standards are referenced in WRF's *Guidelines for Research Priority Program Proposals*, and include specific guidelines outlining the requirements for indirect cost negotiation agreements, financial statements, and the Statement of Direct Labor, Fringe Benefits, and General Overhead. Inclusion of indirect costs must be substantiated by a negotiated agreement or appropriate Statement of Direct Labor, Fringe Benefits, and General Overhead. Well in advance of preparing the proposal, your research and financial staff should review the detailed instructions included in WRF's *Guidelines for Research Priority Program Proposals* and consult the *Instructions for Budget Preparatio*n, both available at https://www.waterrf.org/proposal-guidelines.

Budget and Funding Information
The maximum funding available from WRF for this project is $250,000. The applicant must contribute additional resources equivalent to at least 33% of the project award. For example, if an applicant requests $100,000 from WRF, an additional $33,000 or more must be contributed

by the applicant. Acceptable forms of applicant contribution include cost share, applicant in-kind, or third-party in-kind that comply with 2 CFR Part 200.306 cost sharing or matching. The applicant may elect to contribute more than 33% to the project, but the maximum WRF funding available remains fixed at $250,000. Proposals that do not meet the minimum 33% of the project award will not be accepted. Consult the *Instructions for Budget Preparation* available at https://www.waterrf.org/proposal-guidelines#RPP-instr-budget-prep for more information and definitions of terms.

Period of Performance

It is WRF's policy to negotiate a reasonable schedule for each research project. Once this schedule is established, WRF and its sub-recipients have a contractual obligation to adhere to the agreed-upon schedule. Under WRF's No-Cost Extension Policy, a project schedule cannot be extended more than nine months beyond the original contracted schedule, regardless of the number of extensions granted. The policy can be reviewed at https://www.waterrf.org/policies.

Utility and Organization Participation

WRF encourages participation from water utilities and other organizations in WRF research. Participation can occur in a variety of ways, including direct participation, in-kind contributions, or in-kind services. To facilitate their participation, WRF has provided contact information, on the last page of this RFP, of utilities and other organizations that have indicated an interest in this research. Proposers are responsible for negotiating utility and organization participation in their particular proposals. The listed utilities and organizations are under no obligation to participate, and the proposer is not obligated to include them in their particular proposal.

Application Procedure and Deadline

Proposals are accepted exclusively online in PDF format, and they must be fully submitted before 3:00 pm Mountain Time on Tuesday, November 21, 2023.

The online proposal system allows submission of your documents until the date and time stated in this RFP. To avoid the risk of the system closing before you press the submit button, do not wait until the last minute to complete your submission. Submit your proposal at https://forms.waterrf.org/cbruck/rfp-5245 .

Questions to clarify the intent of this RFP and WRF's administrative, cost, and financial requirements may be addressed to the WRF project contact, Stephanie Fevig at 303.347.6103 or sfevig@waterrf.org. Questions related to proposal submittal through the online system may be addressed to Caroline Bruck at 303.347.6118 or cbruck@waterrf.org.

Utility and Organization Participants

The following utilities have indicated interest in possible participation in this research. This information is updated within 24 business hours after a utility or an interested organization submits a volunteer form, and this RFP will be re-posted with the new information. **(Depending on your settings, you may need to click refresh on your browser to load the latest file.)**

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