



REQUEST FOR PROPOSALS (RFP)

Advancing Anoxic Phosphorus Uptake for Highly Efficient Simultaneous Nitrogen and Phosphorus Removal (5252)

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

- Advance the knowledge of phosphorus (P) removal through anoxic P uptake in biological nutrient removal (BNR); this includes investigating the microbial ecology and approaches for identification of as well as the role of denitrifying polyphosphate accumulating organisms (dPAOs), denitrifying glycogen accumulating organisms (dGAOs), non-canonical PAO, and other denitrifiers that offer advantages in effective anoxic phosphorus uptake and removal with various carbon pools.
- Building on research-to-date, advance the knowledge of dPAO selection and enhancing dPAO activity in practice at pilot- and full-scale.
- Develop design and operational guidelines and control strategies focused on effective full-scale implementation of anoxic P uptake for simultaneous nitrogen (N) and P removal at water resource recovery facilities (WRRFs).

Budget

Applicants may request up to \$200,000 in WRF funds for this project.

Background and Project Rationale

Anoxic P uptake using dPAOs can provide significant cost savings such as reducing aeration demand and using carbon more efficiently for both N and P conversion, but there are significant knowledge gaps and a need for design and operational guidelines. Advancing anoxic P uptake toward full-scale implementation at WRRFs is the main objective of this project.

Biological P removal can be energy and carbon intensive as well as costly, particularly to achieve low P levels. dPAOs are heterotrophic organisms that can use nitrate (NO_3^-) or nitrite (NO_2^-) as an electron acceptor instead of oxygen. Anoxic P uptake using dPAO (and possibly dGAO) and nitrate or nitrite as an electron acceptor can significantly reduce or eliminate aeration needed for aerobic P uptake and carbon use for denitrification by using the same or reduced amount of carbon for N and P conversion, thereby realizing significant cost savings related to reducing aeration demand and using carbon more efficiently. However, significant knowledge gaps remain, and design and operational guidelines are needed. Also, side-stream enhanced biological phosphorus removal (S2EBPR) enrichment (return activated sludge (RAS) or mixed liquor fermentation) for internal carbon-driven denitrification by dPAO and dGAO offers the potential of improving EBPR and anoxic P uptake. Coupling P removal via anoxic P uptake with mainstream short-cut nitrogen removal (e.g., partial denitrification anammox (PdNA), partial nitrification anammox (pNA)) could offer a highly cost-effective approach to N and P removal.

The overall desired outcome of this project is to provide utilities with guidelines and best practices for implementing anoxic P uptake and removal in their BNR processes and sustainably achieving both N and P removal. This project should also advance the knowledge of P removal through anoxic P uptake (potentially with short-cut nitrogen removal processes such as PdNA and/or with carbon enrichment through RAS or mixed liquor fermentation); improve the understanding of operational aspects related to ecology and management of carbon sources (including internally-stored carbon) and alternative electron donors; and enhance dPAO activity in the presence of complex carbon pools.

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 meet the objectives listed above. The following approach is intended as a starting point to address key research gaps including but not limited to:

- Advance the knowledge of anoxic P uptake in N and P removal, including with dPAO as the potential main driver for anoxic conversion of nitrate to nitrite.
- Advance the knowledge of effective dPAO activity for simultaneous nitrogen and phosphorus removal, including enrichment of dPAO and enhancing their activity, potentially through testing novel process concepts at pilot- and full-scale.
- Investigate dPAO/dGAO/other denitrifier microbial ecology. This includes investigating the potentially complimentary role of dGAO in conversion of nitrate to nitrite and the implications for microbial resource management, carbon management, and competition with other denitrifiers, including the impact of the nature of the carbon source on the competition for organic substrate.
- Develop approaches for identification and management of non-canonical PAOs (beyond *Accumulibacter*) that offer advantages in P removal with various carbon pools. This includes those similar to dPAO in terms of recycling polyhydroxyalkanoate (PHA) as well as others that can grow anaerobically by fermenting amino acids and sugars without cycling PHA.

- Provide clear operational guidelines that include:
 - Developing operation and control strategies that enhance anoxic P uptake and dPAO activity (e.g., carbon limitations, electron acceptor routing, aeration regimes, solid retention time (SRT), dissolved oxygen (DO) affinity) and process enhancements (e.g., granule selection or hybrid operation).
 - Identifying key commonly measured parameters needed to monitor/control for optimal dPAO activity and BNR performance.
 - Investigating management of the buildup of denitrification intermediates, such as nitrite, while maintaining anoxic P removal and maximizing N removal.
 - Identifying process control approaches and strategies to limit nitrite accumulation and mitigate associated negative impacts such as the generation of nitrous oxide emissions.
- If feasible, the research team is encouraged to:
 - Potentially advance dPAO-PdN and dPAO-PdNA beyond proof of principal (refer to project 5095 (De Clippeleir et al. Forthcoming) and project 5183 RFP (WRF 2023) in the references section).
 - Potentially advance the knowledge of P removal implementation at WRRFs through anoxic P uptake coupled with any of the following:
 - S2EBPR (refer to project 4975 (Downing et al. Forthcoming))
 - Internally stored carbon (refer to project 5245 RFP (WRF 2023))
 - Short-cut nitrogen removal processes such as PdNA beyond proof of principal (refer to project 5095 (De Clippeleir et al. Forthcoming)) and project 5183 RFP (WRF 2023)

Expected Deliverables

Deliverables should include, but are not limited to, a research report (must use WRF's Research Report Template, which can be found at <https://www.waterrf.org/project-report-guidelines#research-report-template>) and one in-person workshop.

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.

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- De Clippeleir, H. G. Wells, Z. Jia, R. Riffat, M. Ladipo-Obasa, S. Klaus, C. Bott, K. Chandran, C. deBarbadillo, A. Al-Omari, and S. Fevig. Forthcoming. *Mainstream Deammonification with Biological Phosphorus Removal*. Project 5095. Denver, CO: The Water Research Foundation. <https://www.waterrf.org/research/projects/mainstream-deammonification-biological-phosphorus-removal-0>
- Downing, L., P. Dunlap, Y. Tse, F. Sabba, J. Loconsole, I. Alvia, J. Barnard, and A. Gu. 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>
- WRF. 2023. *Advancing Partial Denitrification Anammox (PdNA) Full-Scale Applications (RFP 5183)*. Denver, CO: The Water Research Foundation.
- WRF. 2023. *Unlocking the Advantages of Internally Stored Carbon for Nutrient Removal (RFP 5245)*. Denver, CO: The Water Research Foundation. <https://www.waterrf.org/open-rfps>

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 Preparation*, both available at <https://www.waterrf.org/proposal-guidelines>.

Budget and Funding Information

The maximum funding available from WRF for this project is \$200,000. 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 \$200,000. 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-5252>.

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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