REQUEST FOR PROPOSALS (RFP)

Ozone Nanobubbles (NBs) Technologies for Water Treatment (5237)

Date Posted
Monday, September 11, 2023

Due Date
Proposals must be received by 3:00 pm Mountain Time on Tuesday, November 14, 2023

WRF Project Contact
Grace Jang, PhD, hjang@waterrf.org

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

Project Objectives
The overall objective of this project is to assess and evaluate the potential application of ozone nanobubbles (NBs) for water treatment. The specific objectives of this study are:

- Examine the behavior and performance of ozone NBs with the preferred ozone dissolution technique
- Perform comparative side-by-side studies between ozone NBs and conventional ozone application methods (e.g., fine bubble diffusion, side stream injection, static mixers, etc.)
- Assess how different water quality parameters, such as pH, temperature, and water composition, influence the effectiveness of ozone NBs for removal of various contaminants (e.g., physical, chemical, microbial)
- Assess the potential for bromate formation during ozonation using NBs
- Investigate the scalability and cost-effectiveness of ozone NBs technology as compared to conventional ozone dissolution techniques

Budget
Applicants may request up to $350,000 in WRF funds for this project.

Background and Project Rationale
The application of ozone for disinfection and oxidation of water is commonly practiced worldwide due to its proven effectiveness in inactivating microorganisms, removing organic pollutants, and controlling taste and odor. However, conventional ozone application using macro bubbles can lead to rapid bubble departure from the solution due to high buoyancy, resulting in a short contact time for ozone dissolution in water. In recent years, there has been

growing interest in using NBs technology during ozonation, as NBs exhibit extended solubility in water, thereby significantly enhancing ozone's disinfection capacity and residual activity. The stability and reactivity of NBs depend on factors such as bubble size, zeta potential, and interfacial characteristics. Solution properties, including temperature, pressure, ion concentration, pH, presence of organic matter or impurities, and surfactants, as well as saturated gas concentration, also influence the behavior of NBs.

While several studies have investigated the application of NBs in biological water treatment, water disinfection, membrane defouling, and groundwater and sediment remediation, limited knowledge exists regarding their specific application in water treatment settings. It is imperative to develop a fundamental understanding and explore the potential applications of ozone NBs technology to enhance the effectiveness of ozonation, reduce costs and chemical usage, and foster the development of innovative treatment approaches. Integrating ozone NBs technology into water treatment can revolutionize the field by improving micropollutant abatement efficiency, reducing the size of treatment facilities, and lowering operational times and costs.

This project seeks to provide valuable insights into the performance, interactions, scalability, and cost-effectiveness of ozone NBs for water treatment by addressing specific objectives. The findings from this study will contribute to informed decision-making and support the potential implementation of ozone NBs technology as an innovative water treatment solution.

Research Approach

The proposed research approach for evaluating the use of ozone NBs in water treatment should be comprehensive and systematic. While this RFP encourages proposers to be creative and original, the following approach can serve as a starting point:

1) **Literature Review**: Conduct a thorough literature review to gather existing knowledge and understanding of ozone NB technology, including its generation methods, stability, behavior, and applications in water treatment. This will provide a solid foundation for the research and help identify existing gaps or areas requiring further investigation.
2) **Experimental Testing**: Design and conduct laboratory-scale experiments to evaluate the performance of ozone NBs for selected treatment goals. These goals could include the removal of specific taste and odor compounds and the inactivation of waterborne pathogens such as *Cryptosporidium* (may have to use surrogates). The experiments should investigate the impact of various factors, such as water quality parameters (pH, temperature, alkalinity, calcium, etc.), ozone NB dosage, and contact time on treatment efficiency.
3) **Side-by-Side Comparison**: Perform comparative studies between ozone NBs and conventional ozone application methods. This can involve conducting parallel experiments using macro bubbles and measuring and comparing parameters such as disinfection efficacy, contaminant removal efficiency, and ozone residuals. This comparison will help assess the added benefits and advantages of using ozone NBs in water treatment. Investigate the scalability and cost-effectiveness of NBs technology compared to

conventional ozone applications. Additionally, consider assessing the capability of ozone NB technology to meet regulatory CT (Contact Time) requirements for ozone (such as are the existing ozone regulatory guidelines logical for nanobubble technologies).

4) **Fate and Transport Analysis**: Investigate the fate and transport of ozone NBs in various treatment processes. This involves studying the behavior and fate of NBs throughout different stages of the treatment process, including their interaction with various water constituents, potential agglomeration or coalescence, and potential effects on downstream processes and water quality. Monitoring techniques, such as particle tracking or nanoparticle analysis, can be employed to track the movement and behavior of ozone NBs.
5) **Bromate Formation Evaluation**: Assess the potential for bromate formation during ozonation using NBs. Bromate is a regulated disinfection byproduct that can be formed when ozone reacts with bromide ions present in water. Investigate the factors influencing bromate formation, such as ozone dosage, bromide concentration, pH, and contact time, to understand the risks associated with using ozone NBs and to develop strategies for mitigating bromate formation if necessary.

It is important for proposers to provide details on the experimental setup, methodology, data analysis techniques, and any additional research activities they plan to undertake to address the objectives. Also, the proposer must carefully assess the project's scope in light of the allocated budget and determine the most optimal approach to achieve the project goals. This RFP encourages creativity, so proposers should also consider any innovative approaches, advanced analytical techniques, or novel methodologies that can contribute to a more comprehensive understanding of ozone NB technology in water treatment.

Expected Deliverables
While specific deliverables may vary depending on the proposed research project, here are a few examples of potential deliverables:

- Research report (must use WRF's Research Report Template, which can be found at https://www.waterrf.org/project-report-guidelines#research-report-template).
- Literature review (summarize all previous ozone studies done to date).
- Webcast, conference presentation, etc.
- Peer-reviewed journal article
- Fact sheet, case study, white paper if applicable.

The specific deliverables should align with the proposed research project. This RFP encourages proposers to suggest innovative and relevant deliverables that can effectively communicate and disseminate the research outcomes to maximize the impact of the study.

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.

- Soyluoglu, M., D. Kim, Y. Zaker, T. Karanfil, and J. Byrne. 2023. *Investigation of Nanobubble Technology for the Removal of MIB and Geosmin from Drinking Water.* Project 5070. Denver, CO: The Water Research Foundation.

A copy of the report will be provided upon request.

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 $350,000. 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 $350,000. 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 14, 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-5237.

Questions to clarify the intent of this RFP and WRF's administrative, cost, and financial requirements may be addressed to the WRF project contact, Dr. Grace Jang at 303.347.6112 or hjang@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.

5237 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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