THE Water Research FOUNDATION

Date Posted: Monday, September 26, 2022

REQUEST FOR PROPOSALS (RFP)

Feasibility of Full-Scale Implementation of UV-LED Disinfection (RFP 5173)

Due Date: Proposals must be received by **3:00 pm Mountain Time on Tuesday, December 13, 2022**
WRF Project Contact: Mary Smith, msmith@waterrf.org

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

Project Objectives
Evaluate the effectiveness of ultraviolet (UV) light emitting diode (LED) lights for microbial inactivation and assess the feasibility of using them at treatment plants.

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

Background and Project Rationale
UV disinfection is an established technology widely used in drinking water, wastewater, and reuse facilities. Mercury lamps are often used due to their lower production cost and higher power output. Recently, LED lamps are gaining popularity because of their small design footprint, unlimited cycling, temperature independence, longer life, fast start-up (no warmup), potentially lower energy consumption, and environmental friendliness (they do not contain mercury). However, there is limited knowledge surrounding the effectiveness of LED lamps for microbial inactivation and the feasibility of using them at treatment plants.

Several studies have examined UV-LED disinfection of different microorganisms in drinking water. Inconsistencies in disinfection efficacy were evident in these studies, limiting our understanding of UV-LED technology's effectiveness on microbial deactivation. For example, studies on the disinfection of *E. coli* using UV-LED at 365 nm found ranges of UV dose responses between 13,846 and 55,263 mJ/cm^2 per log inactivation; at 265 nm, UV dose responses ranged between 5.9 and 2.7 mJ/cm^2. Another example of such inconsistency was the use of UV-LED at 255 nm to inactivate MS2. One study reported that a 41 mJ/cm^2 UV dose generated a 3.2 log inactivation. Meanwhile, a different study achieved a 60 mJ/cm^2 UV dose that provided a 2.3 log inactivation. In addition, there have been inconsistent results regarding UV-LED deactivation for other test microorganisms. Discrepancies may be attributed to different experimental conditions and materials between studies. This issue arises because, at this time, no specific protocol exists for typical UV-LED reactor characteristics, and there is no methodology to determine microorganism UV-LED dose response.

For UV-LED technology to replace traditional mercury UV disinfection, it must be as effective or better at disinfection than conventional UV. Few studies suggested that UV-LED is at least as effective as low-pressure UV disinfection. However, other studies have observed wide variations in results. Using UV-LED 255 nm, for example, the inactivation rate (cm^2/mJ) of bacteriophage φ174 was almost double that of conventional UV at 254 nm. Nevertheless, at 280 nm, the inactivation rate was similar to that of conventional UV at 254 nm. These discrepancies across literature might be attributed to differences in reactor design, UV sources, and the microorganism's response to each wavelength and contact time. However, recent investigations have suggested that UV-LED disinfection using multiple wavelengths and pulsed irradiation—or a combination—OBJOBJ approach for full-scale implementation in water treatment plants. There is, however, limited information available in the literature that discusses these features. Additionally, the small surface area (1-4 mm^2) of UV-LED lamps is advantageous, enabling the UV-LED reactors to emit light from different directions and orientations. This allows the creation of unique reactors, which traditional mercury UV reactors cannot achieve.

High capital costs, poor output power, and low wall-plug efficiency have limited the widespread adoption of UV-LED water disinfection technology, therefore resulting in technology adoption being confined primarily to point-of-use batch applications. However, recent advancements in UV-LED manufacturing have significantly reduced the direct cost of LED lamps over the last few years, increased output power, and improved wall-plug efficiency. Even still, there are significant capital costs involved in designing UV-LED disinfection systems for water treatment applications. No studies have been conducted to date that provide a thorough economic analysis of UV-LED systems compared with conventional UV for water treatment applications.

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 above objectives.

The following approach is intended as a starting point:

- Conduct a comprehensive literature review to provide an overall understanding of the application of UV-LED technology for disinfecting drinking water. The review might include an assessment of UV-LED technology versus conventional UV—addressing UV dose responses, contact time, test microorganisms, costs, and any other operational parameters.
- Provide guidance on the feasibility of implementing UV-LED light at new facilities, as well as logistical considerations for transitioning from low/medium pressure lamps to LED lamps at existing treatment plants.
- Conduct bench-scale experiments to demonstrate the efficacy of UV-LED over conventional low/medium pressure UV in disinfecting drinking water. This may include developing a standard methodology and protocol for obtaining quantitative information about the UV dose delivered by UV-LEDs for deactivating microorganisms. The cost and technology readiness level of the proposed approach should be considered.
- Based on the study results, provide an analysis of the feasibility, practical applicability, and economic viability of the UV-LED approach for implementation—compared to traditional UV disinfection.

Questions to be answered through this research include the following:

- Does this technology provide disinfection effectiveness equal to or greater than traditional UV disinfection?
- Is it economically and technically feasible to transition from traditional mercury lamps to LED lamps?
- How do life cycle costs of UV-LED disinfection compare to low/medium pressure lamps?
- Following a power outage, how quickly is the ability to inactivate pathogens restored? How does this compare to mercury lamp-based UV systems?
- How does power consumption per unit volume treated vary for different levels of influent fluid turbidity while still maintaining disinfection effectiveness?
- How can one quantify the potential for fouling in a UV-LED dosing chamber and the maximum recommended time between chamber cleanings before disinfection performance is adversely affected?

Expected Deliverables

The following deliverables are anticipated for this project. Normal font indicates preferred deliverables; italicized font indicates optional deliverables.

- Literature Review
- Research Report
- Webcast, Conference Presentation, etc.
- *Peer-Reviewed Journal Article*
- *Field Demonstration*
- *Web Tool (consider plan for maintenance)*
- *Workshop (consider plan to document workshop)*

A final report should summarize the effectiveness of UV-LED disinfection in comparison with conventional UV, the standard protocol for obtaining UV doses by UV-LED, and the feasibility and practicality of using UV-LEDs in water treatment plants.

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. Conference presentations, webcasts, peer review publication submissions, and other forms of project information dissemination are typically encouraged.

Project Duration

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

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 the WRF document *Guidelines for Research Priority Program Proposals*. The current version of these guidelines is available at https://www.waterrf.org/proposal-guidelines, along with *Instructions for Budget Preparation*. 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#deliverables.

Eligibility to Submit Proposals
Proposals will be accepted from domestic or international 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 $250,000. The applicant must contribute additional resources equivalent to at least 33 percent 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 percent to the project, but the maximum WRF funding available remains fixed at $250,000. **Proposals that do not meet the minimum 33 percent of the project award will not be accepted.** Consult the *Instructions for Budget Preparation* available at https://www.waterrf.org/proposal-guidelines 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, December 13, 2022.

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/222615267744863

Questions to clarify the intent of this RFP and WRF's administrative, cost, and financial requirements may be addressed to the WRF project contacts, Mary Smith at (303) 347-6134 or msmith@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**.**

5173 Utility and Organization Participants

The following utilities have indicated an 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 upon your settings, you may need to click refresh on your browser to load the latest file.)**

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