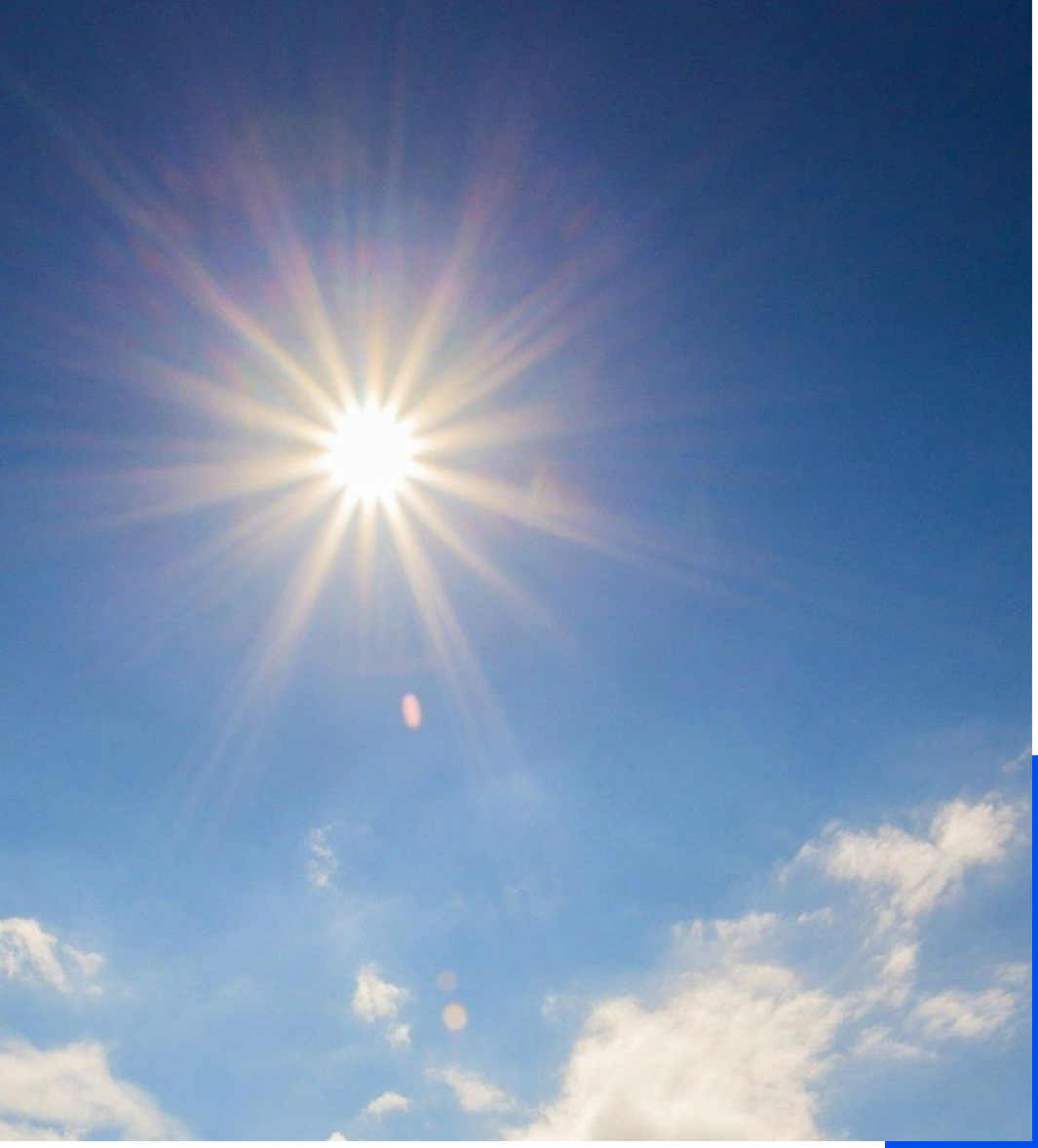

> PFAS are one of the greatest threats to our nation's water supplies due to its high toxicity and relative resistance to degradation.
> Tyler Radniecki, Ph.D

Targeted Photocatalysis for Effective Destruction of Per- and Polyfluoroalkyl Substances (PFAS):

Breakthrough Remediation Advances Using the Ray® Solar Photocatalytic Generator

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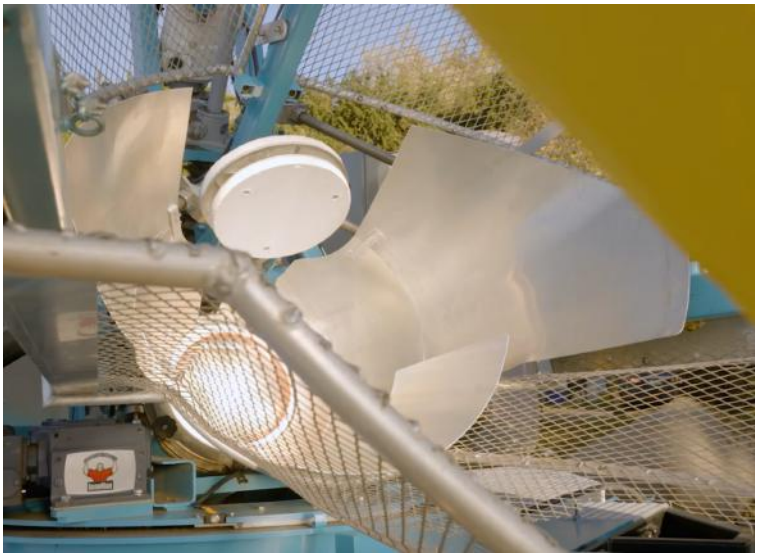
Introduction

Per- and polyfluoroalkyl substances (PFAS) include more than 9,000 man-made chemicals that have been used for decades to resist corrosion from grease, oil and water. They were originally created to help extinguish petroleum fires, and as such have been heavily applied to the environment through the form of aqueous film-forming foams (AFFFs.)

Commonly referred to as "forever chemicals," the wide application and improper disposal of PFAS has caused them to leach into terrestrial, aquatic and atmospheric environments at an alarming rate. Their presence is not only affecting the nature that surrounds us, but our health as well. They have been shown to interfere with the body's hormones, increase cholesterol levels, affect the immune system and increase the risk of developing certain types of cancers.

What is Special about the Ray® Solar Remediation System?

The Ray® System is a breakthrough technology. It is a solar-powered water remediation unit that breaks bonds by concentrating wavelengths including the visible and UV ranges for photocatalysis. This sterilizes and destroys bacteria, while simultaneously breaking carbon structures that constitute oxygen demanding .



Overview of 8' Ray® System

- Autonomous use
- Reaches internal temperatures of up to 900 degrees
- Operates at 120 gph currently- potential for more
- No use of harmful chemicals, gases, or filtration
- Carbon neutral
- Portable, and can work alongside preexisting systems
- Use of solar enables low operational cost
- Made in the USA

Polarizing UV Systems for PFAS Destruction

Photocatalysis is a well documented process with highly proven efficiency. It utilizes solar heat and UV radiation to drive atoms to break their molecular bonds, thus forcing reactions to occur at accelerating rates.

However, this science has been hampered by the relative inefficiencies of UV lamps. Their use presents issues of:

- increased maintenance due to fouling
- high energy demand to generate UV radiation
- singular UV light wavelength
- initial and replacement costs

These limitations have kept this science from being adopted as an effective treatment technology for anything but simple drinking water.

In the Ray® System, photocatalysis is achieved by aiming the large lens at the sun, which is able to concentrate the entire spectrum of UV rays that pass through the atmosphere. This s then directed onto the receiver containing a catalyst, amplifying the effects of the chemical on all water that passes through the system.

In a 2018 report conducted by Oregon State University, the findings stated *"the lens led to a 72 (+/-38)% increase"* in solar irradiance. (Hammervold; Giardina, 2)

The Ray® system utilizes an innovative refracting lens to focus the sun's power into a receiver. The lens is comprised of a series of individually focusing circular prisms, which concentrate the sun's full spectrum of rays on to the process area. The prisms are wavelength selective to distribute the UV, which is concentrated at minimum 50 times the intercepted energy.

By using the free energy of the sun, we overcome the economics and deliver a complete and saturating energy source that overcomes the shortcomings of UV lamps. By using direct sunlight, we deliver all wavelengths.

Limitations of Other Treatments

PFAS have been able to spread so prolifically through the environment because their creation was made to withstand chemical and natural stressors. Multiple physical treatment methods have been deployed, such as activated carbon absorption, ion exchange and membrane separation, but these methods only transfer and concentrate the PFAS from the contaminated water to a second medium. Other forms of remediation such as the use of chemical oxidants and microbial degradation have proved to be either ineffective or too slow to have any sustainable impact.

The lack of viable treatment options has caused many to seek out thermal incineration of PFAS, but the temperature needed to degrade these bonds is 1,800 degrees Fahrenheit, and *"likely induces a secondary atmospheric PFAS pollution due to incomplete combustion."* (Chen)

The Department of Defense has approved 8 PFAS incinerator facilities across the country. One of these, the Norlite incineration facility in Cohoes, New York was linked to higher PFAS concentrations in the surrounding community. AFFF was burned at this site in 2018 and 2019, and in early 2019 researchers from Bennington College tested samples of the surrounding soil and water at Eurofins commercial laboratory. The results detected high levels of PFAS downwind of the plant, indicating that burning these forever chemicals had merely polluted the air instead of destroying them as was hoped.

Testing of the Ray® System

Initial tests have been conducted on the Ray® System that show significant potential to effectively remediate PFAS. *"Of the 18 polyfluorinated alkane species, five showed statistically significant decreases in concentrations..."* (Hammervold)

The PFAS that showed reductions were perfluorobutanoic acid, perfluorohexanoic acid, perfluorooctanoic acid, polyfluoropentananesulfonic acid, and 8:2 fluorotelomer thioether amido sulfonate. Some showed consistent degradation, perfluorobutanoic acid was removed an average of 28 (±3)%, while others had varying results, 8:2 O2-FtAoS decreased an average of 19% (±13)% during the first batch test and 42% (±4)% during the second batch test.

We believe with more testing and better catalyst options, Ray® would show more consistent data. Boron Nitride is an example of a catalyst that has emerging data showing its reactivity with a wide spectrum of both UV and visible light. A catalyst such as this would allow Ray® to activate more of the energy that passes through its lens.

"Photocatalysis has been shown to degrade PFAS but often requires large amounts of energy to provide the light source. The Ray® System has the power to provide UV and visible light for the photocatalytic destruction of PFAS at a fraction of the energy requirements of other photocatalysis systems." Tyler Radniecki, Ph.D.

Works Cited:

Chen, Gongde, et al. "Hydrogen-polarized Vacuum Ultraviolet Photolysis System for Enhanced Destruction of Perfluoroalkyl Substances." *ScienceDirect*, vol. 3, 2021, https://doi.org/100072

Hammervold, Meredith, and Giardina, Forest. Update Report for Focal Technologies: Evaluation of the Ray System to Treat Propylene Glycol and Dairy Manure Effluent. 2017. Oregon State University, Research Report.

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