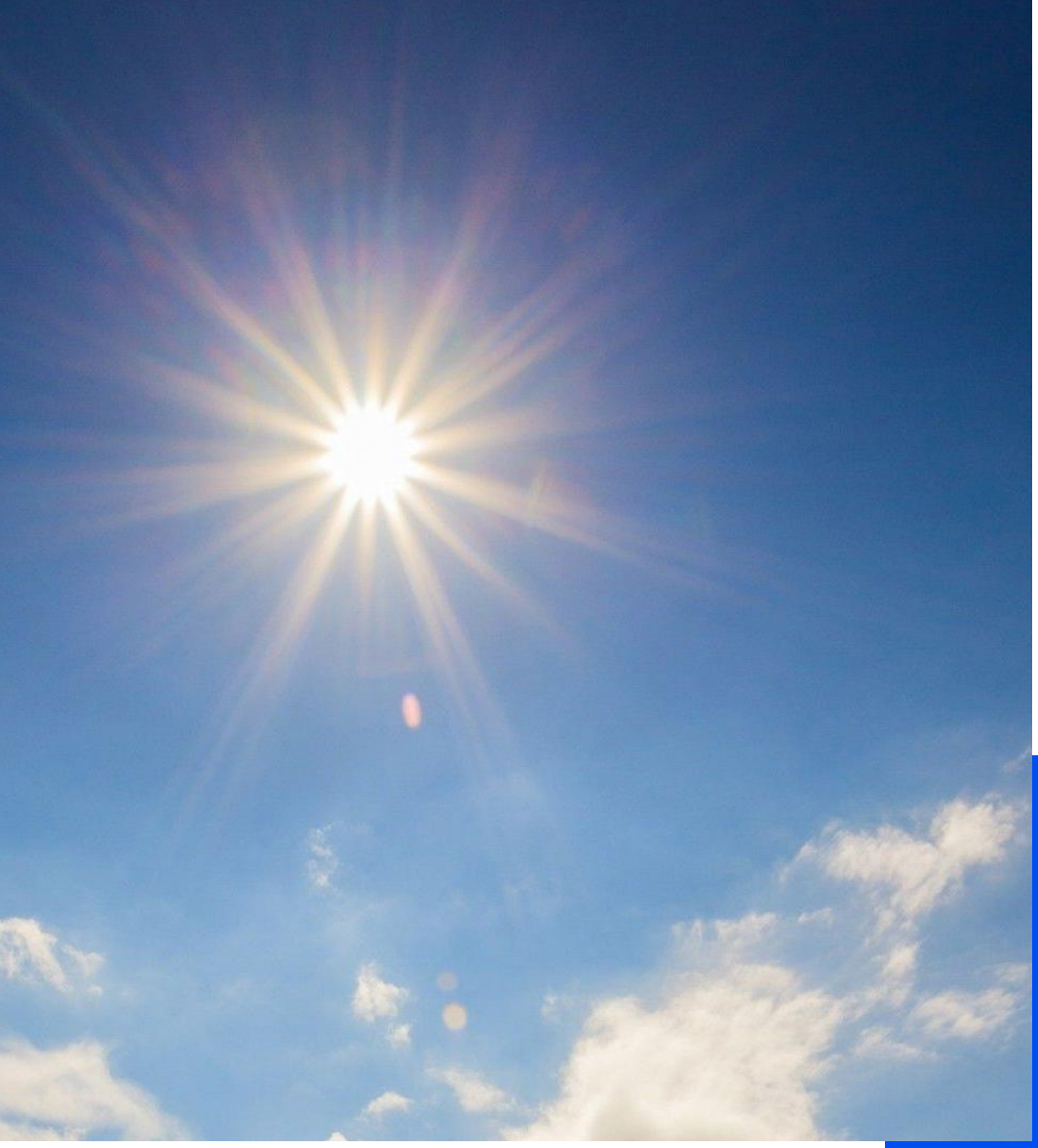

> The Ray® System is remarkable in its ability to utilize UV light, heat and photocatalysis to rapidly sterilize water with minimal energy inputs.
> Tyler Radniecki, Ph.D.

Combining Heat and Photocatalysis for Bacterial Elimination on Agricultural Processing Plants and CAFOs:

Breakthrough Remediation Advances Using the Ray® Solar Photocatalytic Generator

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Introduction

Bacteria in wastewater and water runoff presents huge liability and costly fines for industrial and agricultural producers. Historically, water with total coliform has been treated through intense heat or by injecting it with high amounts of chlorinated compounds. Unfortunately, these treatments are costly for producers to utilize, and bacteria limits in water are often not adhered to.

The EPA lists 1,595 sites that have violated the Clean Water act within the last 3 years in Oregon alone. When it is not properly cleaned, bacteria in water can deteriorate ecosystems in surrounding bodies of water and endanger the health of consumers, fish and aquatic ecosystems. The Ray® unit combines high heat and the well documented use of photocatalysis for bacterial breakdown in a cost effective and easily managed system.

What is Special about the Ray® Solar Remediation System?

The Ray® System is a breakthrough solar-powered water remediation unit. No water treatment system exists on the market today that effectively employs the use of solar thermal energy, UV light and photocatalysis to sterilize and destroy, rather than merely filter or separate, deadly pathogens and bacterias present in wastewater.

Overview of 8' Ray® System

- Autonomous use
- Reaches internal temperatures of up to 900 degrees
- Operates at up to 360 gph currently- potential for more
- Uses no 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

High Heat for Bacteria Kill Off

Heating water to hot temperatures has long been a trusted process to kill pathogens in water riddled with bacterial contaminants. As the temperature rises, the bonds that keep these protein structures together start to break and lead to their ultimate denaturation. On a large scale however, this process can be costly, and often requires the use of off-site hauling to a separate facility, which only adds to the time and price needed to kill *E. coli* and other pathogens.

Unfortunately, bacterium from concentrated animal feeding operation (CAFO) lots and other agriculture processing plants can be spread in runoff water, and each year the U.S has approximately 265,000 illnesses and about 100 deaths from *E. coli* outbreaks alone. It is necessary then to find solutions that enable producers to adhere to preventative measures before outbreaks occur.

In tests conducted in November of 2022, Ray's lens was able to lower both total coliform and *E. coli* from 24,196 MPN/ 100ml to non detectable levels after a one time pass at 170°. Even more impressive, it was able to lower the total coliform to 8.4 MPN/ 100ml and the *E. coli* levels to non detectable at 147°.

A study funded by VertueLab in 2018 all corroborated these results, stating "the unit has an effective kill temperature at 150°, well below the known kill temp for *E. coli*." (Hammervold, 4) The Ray® System was able to kill bacteria at temperatures below what was previously thought possible, due to the combination of Photocatalysis and concentrated UV being applied to the wastewater in congruence with the high heat. The table below shows more tests run on the Ray® system that detail its advanced capability to remediate bacteria.

Date	Temp.	Catalyst	*E. coli*	% removal	Coliform	% removal
13-Feb-18	Standard	--	> 48,392	--	--	--
7-Feb-18	150	TiO2	< 20	99.96%	--	--
13-Feb-18	Standard	--	>120,980	--	--	--
13-Feb-18	150	TiO2	< 20	99.98%	--	--
9-April-18	Standard	--	>241,960	--	--	--
9-April-18	120 w/ air	TiO2	2.419.6	90%	--	--
28-July-21	Standard	--	993,000	--	>1,209,800	--
28-July-21	165	TiO2	ND	100%	104	99.99%

Photocatalysis for *E. Coli* Remediation

Photocatalysis is a well documented tactic with highly proven efficiency. It is the process of using light energy to drive pairs of chemical reactions, thus allowing these reactions to occur at an accelerated rate.

The use of a photocatalytic cleaning method using ultraviolet lamp light to sterilize bacteria, *E. coli* and other harmful pathogens, originally pioneered by Puralytics, is in use in the industry, but requires significant levels of electricity to operate, can only clean limited amounts of water at a time and has high operational costs. UV lamps have a limited throughput capacity and are not generally compatible with the flow needs of a large commercial or industrial site.

In the Ray® System, photocatalysis is achieved by aiming the large lens at the sun, which is able to concentrate all UV rays that pass through the atmosphere. This energy is 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 previously discussed process of heating the water to high temperatures works in conjunction with the photocatalytic process to treat bacteria at a flow rate of 5 gpm. The same report found that "The thermal enhancement capability of the Ray® System provided superior disinfection of dairy manure effluent (containing *E. coli*) compared to UV and TiO2 photocatalysis." (Hammervold, 4)

Ammonia Production

Ammonia is produced as an end product in plant and animal waste decomposition. When added back into the soil, it's nutrients act as fertilizer for the next season of crops. The Ray® system generates useable ammonia as a byproduct of it's remediation process.

"An additional benefit of the Ray® System for dairy manure sterilization is the increase of ammonia and phosphorus in the effluent, creating potential for its use as a fertilizer of crops for human consumption. The ammonia increased by 26+/- 8% and phosphate increased by 18+/- 4%." (Hammervold, 4)

"As the disposal of CAFO waste becomes more challenging, the Ray System offers a solution that produces disinfected water with elevated levels of ammonia and phosphorus suitable to irrigation and fertilization." Tyler Radniecki, Ph.D.

The use of UV radiation to kill bacteria in wastewater has previously produced inconsistent results because of the high potential turbidity of the effluent. Bacteria can be shadowed by small particulates and suspended solids, allowing them to escape exposure. The Ray system overcomes this obstacle by providing high temperatures as well as UV radiation through the concentration of the full solar spectrum. Dairy effluent treated by the Ray system has consistently tested non detectable for E-Coli even at temperatures below the known kill temp of 165F.

Works Cited:

Hammervold, Meredith , et al. *Final Report for Oregon BEST (Now VertueLab): Study of Solar Concentration from the Remediation of E. Coli and the Breakdown of Organics in Wastewater Using the Ray Solar Concentration System Provided by Focal Technologies*. 2018. Oregon State University, Research Report.

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