In-lake Intervention Strategy

Limited Supporting Field Data

Ultraviolet (UV) exposure is an advanced oxidation technique that is used most commonly with other technologies in large facilities to disinfect treated water. UV exposure works by transferring electromagnetic energy from a UV source (bulb) to inactivate organism DNA, thereby eliminating reproduction and growth. UV-C light is typically used in treatment processes due to its short wavelength (190–280 nm). This type of UV light is highly energetic and has strong mutagenic effects on the DNA of most organisms (Pattanaik, Schumann, and Karsten 2007). UV exposure has been experimentally shown to oxidize microcystins and cylindrospermopsin but at extremely high doses that are not feasible for an in-field application (USEPA 2019). It has been shown to be effective at oxidizing cyanotoxins in production-scale treatment operations when used in tandem with a catalyst, such as hydrogen peroxide (Afzal et al. 2010).

Using UV light to control HCBs in surface waters is not an established technique. Some studies have shown experimentally that UV exposure can inhibit HCB growth (Alam et al. 2001, Sakai et al. 2007). While Alam et al. (2001) reported that boats equipped with UV lamps were used in several eutrophic lakes in Japan to control algal growth, detailed reports of field data could not be found. Currently, this approach is considered limited due to a lack of validated field applications specifically for HCBs. An alternative application strategy is the deployment of boats with UV lamps to stunt the growth of an active bloom. As reported indirectly in Alam et al. (2001), boats with UV lamps show some feasibility for smaller, shallow lakes. This approach has been piloted in Lake Tahoe to control invasive weeds (Tahoe Resource Conservation District 2018).

EFFECTIVENESS

- Water body type: Pond, lake/reservoir
- Surface area: Small
- Depth: Shallow
- Trophic state: Oligo-/mesotrophic
- Any mixing regime
- Water body use: Recreation, drinking water (treatment), treated wastewater/effluent
- Water bodies with low turbidity

NATURE OF HCB

- HCB types: Could be effective for planktonic or benthic blooms
- Repeating HCBs; useful for drinking water treatment in reservoirs and other source waters with chronic, recurring HCBs
- Approach is non-targeted; other microbes and photosynthetic organisms could be susceptible to DNA damage (Pattanaik, Schumann, and Karsten 2007)
- Potential as immediately effective strategy by suppressing cyanobacterial growth following exposure
- Intervention strategy

ADVANTAGES

- UV exposure (UV-C) has been shown to inhibit growth of *Microcystis aeruginosa* for several days in laboratory studies, even at relatively low doses (37 mW/s/cm^2)
- Technique does not directly produce waste by-products although there is some experimental evidence that UV exposures have the potential to photoconvert compounds such as pharmaceuticals (Canonica, Meunier, and von Gunten 2008)

LIMITATIONS

- UV exposures alone are not effective at oxidizing cyanotoxins, but they may be effective if used in tandem with a catalyst (for example, hydrogen peroxide)
- Limited peer-reviewed evidence to support the use of UV exposures to control algal or cyanobacterial growth in lakes
- Boat deployment requires depth-adjusted lamps to accommodate the vertical migration of cyanobacteria in the water column
- Effectiveness can be dampened by turbidity and dissolved organic carbon content in water body (Afzal et al. 2010)

Figure C-13. This boat built by Inventive Resources has a panel of UV lights that is lowered to expose aquatic invasive plants to UV light.

Source: Tahoe Daily Tribune 2017. Used with permission.

COST ANALYSIS

Large-scale use of UV treatment on a process scale is expensive, but it is less costly than other advanced oxidation and disinfection processes (Dore et al. 2013). There are few cost analyses for UV exposure via boat, specifically for management of HCBs. Labor costs for UV exposure for invasive weed control in Lake Tahoe were estimated at $28,000 for a UV-C treatment system 160 ft^2 across 1 acre (Tahoe Resource Conservation District 2018); capital costs were not provided.

Relative cost per growing season: UV exposure

ITEM	RELATIVE COST PER GROWING SEASON
Material	$$$
Personal Protective Equipment	$$
Equipment	$$$
Machinery	$$$
Tools	$$$
Labor	$$$

CASE STUDY EXAMPLES

Laboratory-scale: Tao et al. (2010) conducted a laboratory study comparing the effects of UV-C exposure on the growth of *Microcystis aeruginosa* and three green algae. UV-C exposures of 20–200 mJ/cm^2 were shown to suppress the growth of *M. aeruginosa* for 3–13 days following a dose-dependent pattern.

Exposure to >100 mJ/sq cm resulted in the death of most exposed cells. Exposures ranging from 20 mJ/cm^2 to 50 mJ/sq cm had sublethal effects. The three green algae did not experience significant effects across the 20–200 mJ/sq cm exposure range, suggesting that *M. aeruginosa* is more sensitive than other non-HCB taxa.

This suggests that UV-C treatment may be a relatively specific intervention strategy that may have minimal impact on other algae in the environment.

O&M Costs	$$$
OVERALL	**$$$**

REGULATORY AND POLICY CONSIDERATIONS

Using UV exposure to treat HCBs in the field may require permitting and reporting. From the Lake Tahoe example, permits were acquired from the Tahoe Regional Planning Agency, and an authorization letter was obtained from the U.S. Army Corps of Engineers. Other regulatory agencies (the Lahontan Regional Water Quality Control Board and California Department of Fish and Wildlife) were contacted and offered consent or requested incorporation of specific monitoring parameters (Tahoe Resource Conservation District 2018). Process-level applications for use of this technique would likely require permitting similar to the procedures above.

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