Planktonic:

In-water Prevention and Intervention Strategy
Limited/Emerging Supporting Field Data

Benthic:

In-water Prevention and Intervention Strategy
Limited Supporting Field Data

Several research groups have explored the possibility of controlling cyanobacterial blooms using natural biocidal compounds or synthetic analogs. These compounds are not one group or a derivative of a similar group or classification of molecules. Instead, they represent natural or synthetically modified extracts from various sources. By definition, a *biocide* is any compound (preservative, insecticide, disinfectant, pesticide, herbicide, fungicide, etc.) that is used for controlling a microorganism that is harmful to human or animal health (USEPA 2019). These organic biocides can range in algal and cyanobacterial targets, and there is an extensive literature of possible ecological end points. In some cases, it is not known how these compounds function; only observations of the effects (for example, algistatic or algaecidal and cyanostatic or cyanocidal) these biocides may have on target organisms are available. In some cases, compounds registered as biocides with USEPA for the control of cyanobacteria are used for limited instances, such as industrial cooling waters and biofouling, and not for surface recreational water bodies.

In general, organic biocides can be broken down into two categories: (1) those that are extracted from plants and (2) those that are natural derivatives of specific metabolites of other microorganisms or plants (NEIWPCC 2015). One potential example of a commonly used, known natural biocide is barley and rice straw extracts, which is expanded upon further in its own strategy.

Various natural compounds have been considered for their potential activity against cyanobacterial blooms and cyanotoxins, including:

- barley straw and its extracts
- L-lysine
- tellimagrandin II
- tryptamine
- nonanoic acid
- β-ionone
- geranyl acetone

While the above is not an exhaustive list of all natural biocidal compounds, several compounds have been examined (NEIWPCC 2015), generally in small-scale studies. Broader ecological impacts may not be known or fully understood. Exhaustive reviews of natural compounds, such as those conducted by Shao et al. (2013), note that many of these compounds may only be weakly cyanocidal or only exhibit inhibitory effects at very high concentrations. Additional concerns are that some organic biocide compounds can themselves be sources of nitrogen or phosphorus, important for additional algal or cyanobacterial growth. Use of some of these compounds, such as L-lysine, may enhance eutrophication by introducing exogenous sources of nitrogen.

PLANKTONIC AND BENTHIC
EFFECTIVENESS • Varies depending on the biocide and its application
NATURE OF HCB • Since this is not a homogeneous group of compounds, the product will vary for the nature of each HCB. For USEPA-approved products, follow the application guidance for the nature of the HCB bloom experienced. • Prevention and intervention strategy
ADVANTAGES • Cost can be lower, depending on the organic biocide and the source, compared to chemical algaecides • Some extracts can be prepared on site with minimal equipment • Some natural compounds may degrade with no off-target effects noted

LIMITATIONS

- Limited documented application for all organic biocides as an intervention technique for HCBs
- Depending on mechanism of action, cyanotoxin release can occur
- Some risk of enhancing eutrophication in the use of several compounds
- Human and animal toxicity data are limited
- High purity extracts may be cost-prohibitive to effectively control blooms

COST ANALYSIS

Estimating cost is difficult for this technique due to the numerous variables. The cost and difficulty in generating the compound is a limiting factor, as is “growing” the source material. Some material, such as L-lysine, can be extracted in abundance at low cost. Others, as described in the literature, require several purification steps to isolate the targeted compound. In general, the simpler the extraction method, the lower the cost.

Some specialized equipment, such as sprayers or on-site grinders, may need to be purchased if the extract must be prepared from fresh material.

Relative cost per growing season: Organic biocides

ITEM	**RELATIVE COST PER GROWING SEASON**
Material	$–$$$
Personal Protective Equipment	$–$$
Equipment	$–$$
Labor	$
O&M Costs	$
OVERALL	**$$**

REGULATORY AND POLICY CONSIDERATIONS

Some organic biocides already have USEPA registration. Additional products are registered as organic biocides, but only for application in specific environments. Some products, though naturally derived, have not been evaluated for short- or long-term toxicity in humans or other aquatic organisms and may pose a hazard. A “natural” or “organic” product is not necessarily safe and could have greater impacts on the ecosystem than the HCB it is purported to treat.

CASE STUDY EXAMPLES

Dianch Lake, China: The cyanocidal effects of L-lysine and malonic acid were evaluated in enclosures with blooms of *Microcystis aeruginosa* (Kaya et al. 2005).

Three enclosures, measuring 10 m by 10 m by 1.3–1.5 m deep, were established and monitored over 28 days. Enclosure A served as the control, B served as L-lysine alone, and C served as L-lysine + malonic acid.

Upon initial spraying, blooms resolved in both enclosures B and C; however, within 7 days a rebound bloom of *M. aeruginosa* appeared in enclosure B.

No rebound bloom was documented in enclosure C, and enhanced macrophyte growth was observed.

By the end of 28 days, no recovery of L-lysine or malonic acid could be detected, indicating that possible complete degradation of these compounds had occurred.

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