Planktonic:

In-water Prevention Strategy
Substantial Supporting Field Data

Benthic:

In-water Prevention Strategy
Limited Supporting Field Data

Barley straw (*Hordeum vulgare*) has been used for over four decades to prevent the growth of cyanobacteria. Initial reports showed widespread success in the United Kingdom, and barley straw deployment has spread to the United States in the past 20 years (Sellner and Rensel 2018). Decomposition of barley straw leads to the breakdown of lignin-containing cell walls within the straw. Lignin decomposition produces two types of residues that limit cyanobacterial growth. Some are specific compounds that individually inhibit cyanobacteria, while others yield strong oxidizing agents that rapidly reduce cell viability. For details and examples, please see Huang et al. (2015), Matthijs et al. (2012), Pillinger, Cooper, and Ridge (1994), Ridge and Pillinger (1996), Xiao et al. (2010), and Xiao et al. (2014).

The general procedure is as follows: 1–1.5 months prior to an expected HCB, stake or otherwise secure <1-year-old, fungicide-free bales of barley straw into the littoral zone of ponds, lakes, rivers, or streams. Bales should be applied at a rate of 7 bales/acre, with several bales saved to deploy halfway through the summer. Bales should be reapplied each year thereafter, again saving some bales for mid-summer deployment. Ranges for barley straw treatment of cyanobacteria in other systems are 6–50 mg barley straw/L in longer residence time waters, such as lakes or reservoirs (Sellner and Rensel 2018).

PLANKTONIC AND BENTHIC
EFFECTIVENESS • Water body type: Pond, lake/reservoir, bay/estuary, rivers/streams • Any surface area or depth • Any trophic state • Any mixing regime • Water body uses: Recreation, drinking water
NATURE OF HCB • All HCB types • Singular or repeating HCBs • Toxic and nontoxic HCBs • Prevention strategy
ADVANTAGES • Effective for most HCBs • Prevents HCBs and, therefore, any cyanotoxin accumulations • Used in many areas • Cost is low if bales are purchased from a farmer • Securing bales along the shoreline is easy • No impact on submerged plants or fish • Is an unregistered algaecide, so may be deployed by individuals, groups, etc., but not by licensed applicators
LIMITATIONS • Will work on most systems, but very large lakes would require significant staff effort for bale deployment • Possible open-water obstruction, so the U.S. Army Corps of Engineers may need to be contacted • Straw decomposition products include tannins, a concern for removal in drinking water facilities • A small midsummer bale addition may be required • Limited application in high flow environments

This technique (7 bales/acre) is effective for most ponds, lakes, reservoirs, and low-salinity estuarine areas and is even more effective if enriched with fungi to aid in lignin decomposition (Sellner et al. 2015). There are some concerns about tannin removal in drinking water facilities from decomposing straw. This technique will not work if applied after the HCB has appeared, and it will not be as effective if the bales are placed in low-light or dark areas. Straw is used in eutrophic systems where blooms have historically occurred; hence, their decomposition results in minimal nutrient additions relative to available levels for bloom growth.

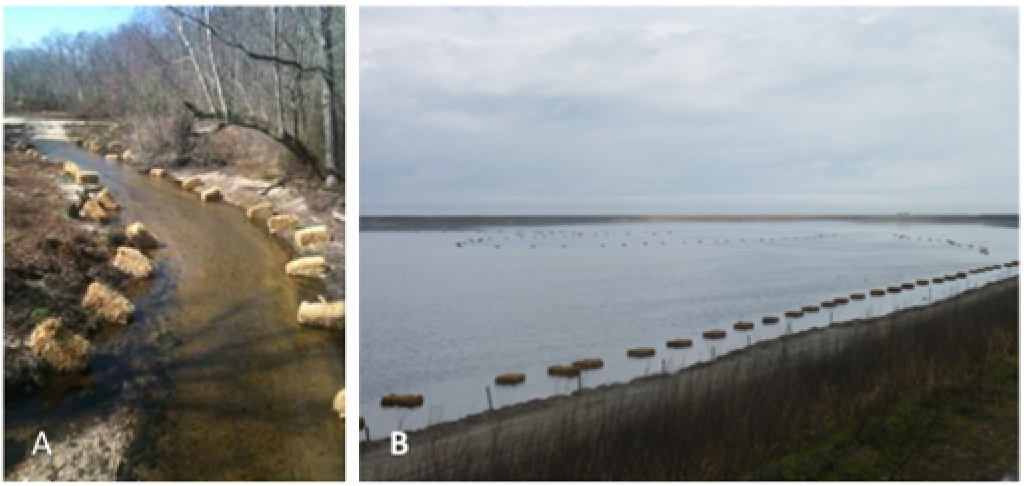

Figure 1. (A) Barley straw lining a stream entering an HCB-dominated lake in eastern Maryland and (B) along the shoreline of a brackish lagoon in Chesapeake Bay.

Source: A–Place, B–K. Sellner.

Other similar options are found in Effiong et al. (2020). Rice straw inhibits *Microcystis aeruginosa* in the laboratory (Park et al. 2006), was used effectively in Nile tilapia ponds (Eladel, Abd-Elhay, and Anees 2019, Shahabuddin et al. 2012), and inhibited *Anabaena* in laboratory experiments (Eladel et al. 2019). Using lake water in aquaria, Tomasko, Britt, and Carnevale (2016) reported that dried cypress leaves at 1.51 g/39 L were more inhibitory to cyanobacteria than equal additions of barley straw.

COST ANALYSIS

Costs for fungicide-free barley straw bales from farmers are inexpensive relative to retail prices from landscape or pond supply companies, where they can be 5–10 times more expensive. Implementation requires labor to secure bales in the littoral zone and may require a small midsummer bale addition.

Cost analysis per growing season: Barley straw

ITEM	RELATIVE COST PER GROWING SEASON
Material	$
Equipment	$
Labor	$
OVERALL	**$**

REGULATORY AND POLICY CONSIDERATIONS

The only limitations for bale deployment are aesthetics (viewsheds) and boating obstructions if bales are secured in open water.

CASE STUDY EXAMPLES

Williston Lake, Denton, Maryland, United States: 500 barley straw bales were deployed over 67 acres of an incoming stream and shoreline of Williston Lake from April to May while the lake was partially drained, resulting in the lake remaining free of *Microcystis aeruginosa*. Microcystin and anatoxin-a concentrations were below recreational exposure levels in the first year, followed by absence of the species and cyanotoxins in subsequent years (Sellner et al. 2015).

Ponds, drainage ditches, and lakes, United Kingdom and Ireland: Barley straw was effective in reducing *Oscillatoria agardhii* from 10,000 filaments/mL to nondetectable levels in a 6-ha lake after 3 weeks of exposure. Lake managers for 29 other water bodies indicated dramatic cyanobacteria reductions following barley straw additions (Newman and Barrett 1993).

Potable water reservoir, Aberdeen, Scotland: Approximately twice/year barley straw treatment (6–28 g/m3) of a reservoir from 1993 to 1998 substantially reduced cyanobacteria (Barrett, Littlejohn, and Curnow 1999).

Derbyshire Reservoir, United Kingdom: Cyanobacteria were significantly reduced when 50 g/m3 and 25 g/m3 of barley straw were added to a disused UK water supply reservoir (Everall and Lees 1996, 1997).

Pond, Dublin, Ireland: Barley straw additions (25–50 g/m2) to the pond at the Tolka Valley Park in Finglas, Dublin, prevented growth of *Lyngbya* mats (Stack and Zhao 2014).

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