Planktonic:

In-water Intervention Strategy
Substantial Supporting Field Data

Benthic:

In-water Intervention Strategy
Emerging Supporting Field Data

HCBs go through natural growth and die-off cycles, often driven by seasons (Yamamoto and Nakahara 2009). Consider monitored natural attenuation (MNA) for the water body if your community is interested in more passive and less costly HCB management strategies. MNA may be feasible for an HCB if exposure risks can be controlled. Even if a more active approach is preferred, in certain cases MNA may be the only practical option—for example, if the affected water body is too remote or too large to be cost-effectively treated through an imposed engineered solution. Similarly, if the HCB occurs late in the growing season or after the recreational season is over, there may not be support or funding to invest the resources needed for active bloom treatment and management. On the other hand, if the water body is used as a drinking water source, MNA may not be an option (see Section 5 in HCB-1 (ITRC 2021)).

Figure 1. Signage instructing citizens not to drink pond water.
Source: Eric Roberts, 2019.

MNA is fundamentally a risk management strategy. This means that stakeholders will need to be comfortable temporarily living with a controlled level of risk. It also means that the risks will need to be regularly reassessed as the character and toxicity of the bloom changes through its life cycle—and as uses of and exposures to the water body evolve seasonally. Cyanotoxins also have variable persistence in natural systems, from days for anatoxin-a to over 200 years for microcystin in lake sediments (Stevens and Krieger 1991, Zastepa et al. 2017). Depending on stakeholder use of the affected water body, varying degrees of control measures may be needed to mitigate potential exposure pathways. For example, if the bloom-affected water is within a sparsely populated residential community or remote, isolated area, posting warning signs along the shore may be adequate. However, in more densely populated communities, signage will probably need to be accompanied by recurring advertising on webpages or in community publications, email distributions, homeowner association member portals, or newspapers. More concepts and approaches for keeping the public informed can be found in Section 5 of HCB-1 (ITRC 2021).

A successfully and safely implemented MNA approach will likely include several key elements:

- Defining the problem: To adequately address the problem, answer questions like:

    - What is the dominant cyanobacterium or cyanobacteria? Can it/they be expected to attenuate as planned?
    - Where is the bloom in the water column (surface scum, subsurface layer, dispersed, or benthic)?
    - How does the dominant cyanobacterium or cyanobacteria respond to expected seasonal changes?
    - Is it reasonable to expect that the bloom will attenuate?
    - Are cyanotoxins present?
    - In what part of the growing season is the bloom occurring?

- Identifying and controlling exposure risks: You must also find the answers to questions like:
    - Is the water body a drinking water source?
    - Is the water body used for swimming?
    - Is the water body used for fishing? If so, is it a catch and release water body?
    - Is the water body in a remote location, or in a populated area with domesticated animals?
    - Do livestock have access to the water?
    - Is wildlife exposure to the bloom a concern?
    - Can signage and other communication tools be expected to adequately inform the public?
    - Is the bloom occurring during the recreational season?
    - Are there other news or social media means of effectively communicating exposure risks to the community?

- Monitoring the bloom and protective controls: Regularly monitor and test the water to answer questions like:
    - How are cyanobacteria counts changing?
    - What changes are occurring in dominant cyanobacteria species?
    - Are cyanotoxins being produced? If so, are they at levels of concern?
    - Is the bloom causing any unforeseen problems?
    - Are there indications the bloom will not attenuate when expected?
    - Is signage being maintained?
    - Are public notices or other communications continuing?
    - Is the public adhering to advisories?
    - Is public sentiment changing?

- Bloom monitoring generally includes tracking cyanobacteria population densities, species prevalence, and the presence and concentrations of cyanotoxins. USEPA (2019) recommends a sequential approach to monitor blooms. Initially, visual indications of bloom formation and growth may be evaluated by field instrument scans of levels of chlorophyll, phycocyanin and phycoerythrin. Visual and field analytical indications of bloom formation or expansion may then be further assessed by laboratory phytoplankton identification and counts of cyanobacteria. Elevated cyanobacteria abundances may trigger subsequent testing for and quantification of cyanotoxins.

- Planning for contingencies: Have plans in place that address questions like:
    - What active remedies will be considered if MNA ceases to be viable?
    - Is funding in place in case an alternative to MNA should be implemented?
    - Have vendors, suppliers, or other resources been identified if active treatment becomes necessary?

PLANKTONIC AND BENTHIC
EFFECTIVENESS • Any water body type • Any surface area or depth • Any mixing regime • Any water body use • Confined to bloom area • Dissipation may occur through natural cycles

NATURE OF HCB
• Surface, subsurface, and benthic HCBs • Toxic and nontoxic HCBs • Almost any area except perhaps a drinking water source • Intervention strategy
ADVANTAGES
• Low cost relative to active, engineered remedies • No expertise, infrastructure, or special equipment required • No chemical additives or physical manipulations • No wastes or by-products
LIMITATIONS
• May or may not yield a bloom decline (Van den Wyngaert et al. 2011) • Substantial staff time for signage, outreach, and monitoring • Requires outreach to local residents and lake users for threat, aesthetics of the water, and recreational limits • Untreated nascent or resident cyanobacteria populations may re-seed the water body (Preston, Stewart, and Reynolds 1980) • Recurrent monitoring is often needed to reassess risks

COST ANALYSIS

The primary costs are for producing and distributing outreach materials, signage for local water body users, labor for posting and removing signs, and labor for monitoring water quality conditions. In addition to monitoring during an active bloom event, some monitoring should also be considered to document bloom dissipation or persistence.

Relative cost per growing season: MNA

ITEM	RELATIVE COST PER GROWING SEASON
Labor	$
O&M Costs	$
Occasional Monitoring	$
OVERALL	**$**

REGULATORY AND POLICY CONSIDERATIONS

If the water body is a public water supply source, the municipal authority or water purveyor may need to actively treat the HCB rather than take the MNA approach. For treatment, regulatory approvals or permits may be needed. However, careful consideration and planning should precede the selection of MNA, including soliciting input from stakeholders and securing public consensus.

REFERENCES

ITRC. 2021. “Strategies for Preventing and Managing Harmful Cyanobacterial Blooms (HCBs).” Washington, D.C.: Interstate Technology and Regulatory Council. Strategies for Preventing and Managing Harmful Cyanobacterial Blooms Team. https://hcb-1.itrcweb.org/.

Preston, T., W. D. P. Stewart, and C. S. Reynolds. 1980. “Bloom-forming cyanobacterium *Microcystis aeruginosa* overwinters on sediment surface.” *Nature* 288 (5789):365-367. doi: https://doi.org/10.1038/288365a0.

Stevens, D. K., and R. I. Krieger. 1991. “Stability studies on the cyanobacterial nicotinic alkaloid anatoxin-A.” *Toxicon* 29 (2):167-79. doi: https://doi.org/10.1016/0041-0101(91)90101-v.

USEPA. 2019. “Recommendations for Cyanobacteria and Cyanotoxin Monitoring in Recreational Waters *EPA 823-R-19-001*.” https://www.epa.gov/sites/production/files/2019-09/documents/recommend-cyano-rec-water-2019-update.pdf.

Van den Wyngaert, Silke, Michaela M. Salcher, Jakob Pernthaler, Michael Zeder, and Thomas Posch. 2011. “Quantitative dominance of seasonally persistent filamentous cyanobacteria (*Planktothrix rubescens*) in the microbial assemblages of a temperate lake.” *Limnology and Oceanography* 56 (1):97-109. doi: https://doi.org/10.4319/lo.2011.56.1.0097.

Yamamoto, Yoshimasa, and Hiroyuki Nakahara. 2009. “Life Cycle of Cyanobacterium *Aphanizomenon flos-aquae*.” *Taiwania* 54. doi: https://doi.org/10.6165/tai.2009.54(2).113.

Zastepa, A., Z. E. Taranu, L. E. Kimpe, J. M. Blais, I. Gregory-Eaves, R. W. Zurawell, and F. R. Pick. 2017. “Reconstructing a long-term record of microcystins from the analysis of lake sediments.” *Science of The Total Environment* 579:893-901. doi: https://doi.org/10.1016/j.scitotenv.2016.10.211.