Planktonic:

In-water Prevention Strategy
Limited Supporting Field Data

Benthic:

In-water Prevention Strategy
Limited Supporting Field Data

Artificial floating vegetated islands have been employed since the 1970s and 1980s for removing nutrients from ponds, lakes, reservoirs, and brackish bays, thus discouraging the algal/cyanobacterial blooms that are favored by high nutrient levels (Hoeger 1988). Floating wetlands have been deployed many times in Asia (Lu, Ku, and Chang 2015, Ning et al. 2014). Islands of various sizes, materials, and designs have been constructed to provide platforms for suspending a variety of emergent plant vegetation. The vegetation is integral to the designs, because the plants take up dissolved nutrients through their roots, which are suspended in the aquatic ecosystem.

This "hydroponics-like" approach for nutrient capture is conceptually and theoretically sound (Wang and Sample 2013). Plant roots suspended in the water below the islands continually sequester nutrients from the water. Development of microbial communities attached to the roots of the plants further increases the drawdown of dissolved nutrients (Masters 2012). Periodic harvesting of plant material from the island results in a net removal of nutrients from the system.

PLANKTONIC AND BENTHIC
EFFECTIVENESS • Water body type: Pond, lake/reservoir, river • Surface area: Small • Depth: Shallow • Trophic state: Eutrophic, hypereutrophic • Any mixing regime
NATURE OF HCB • All HCB types • Singular or repeating HCBs • Toxic and nontoxic HCBs • Targets all algal species • Prevention strategy
ADVANTAGES • Reduced nutrient loads by uptake and removal of plant tissue • Reduced light penetration into the water column, reducing primary production • Reduced wind-driven circulation may reduce deep mixing of the water column, reducing nutrient transport • Thermal insulation may reduce high water temperatures in the summer, constraining cyanobacterial growth • Plant roots provide increased biotic surface area for microbial growth, enhancing nutrient removal • Plant root microbes may increase predation on the planktonic microbes • Application has been carried out in freshwater and brackish environments • Can be harvested
LIMITATIONS • High cost of island design, construction, deployment, maintenance, harvesting, and replanting • Substantive nutrient reduction in the treated water body requires prolonged use • Rate of nutrient removal must be high relative to internal loads and greater than external loading • Plant growth is most rapid and luxurious at high (hypereutrophic) nutrient concentrations (Cao and Zhang 2014); efficacy at "environmentally relevant" concentrations is not clear • Reduced wind-driven circulation may reduce deep mixing of the water column and lead to greater stratification and increases in nutrients from low-oxygen bottom sediments

The effectiveness of this approach for nutrient reduction is determined by a number of factors, and the field is still optimizing the approach (Dunqiu et al. 2012). Ultimately, this technique's effectiveness depends on the surface area covered by islands relative to the volume of the water body, as well as the magnitude of internal and external nutrient loading relative to the rate of nutrient removal by the islands. The rate of nutrient capture and removal by these islands is dependent not only on island size but also on the type of vegetation employed and environmental factors that affect primary production by the plants (for example, light, temperature, and nutrient concentrations in the water body). These features are difficult to quantify, making it difficult to create a generalized approach that will be universally successful. The Chesapeake Bay Program convened two expert panels to set nutrient removal efficiencies and concluded that these features were appropriate for stormwater ponds and not open waters, where 10%–50% aerial coverage would result in increasing nutrient removal credit toward total maximum daily load (TMDL) limits (Schueler, Lane, and Wood 2016).

A number of anecdotal reports or one-off success stories have claimed effectiveness, but relatively few scientific studies have clearly demonstrated that the approach can result in significant nutrient reduction (Geng et al. 2017, Lu, Ku, and Chang 2015, Vázquez-Burney et al. 2015). Successes are also reported in non-peer-reviewed fact sheets and reports, as well as abstracts from conference proceedings or other documents and publications that have not been peer-reviewed. Growth and nutrient uptake by several candidate plant species have been tested on artificial islands (Geng et al. 2017, Yao et al. 2011, Zhu, Li, and Ketola 2011), demonstrating that nutrients are indeed acquired by the island plants. However, studies demonstrating that such nutrient uptake and removal is a significant fraction of the total nutrient load of the aquatic ecosystem are scarce.

The anticipated or supposed effect of floating islands is a reduction in nutrient concentrations, resulting in overall reduction of algal/cyanobacterial growth. However, it is also possible (but largely untested) that shifts in plankton community structure away from harmful or noxious algal/cyanobacterial species may occur due to the activities of the plants or their attendant root microbes. In addition, reductions or changes in the plankton community because of reduced light penetration (due to the presence of the floating islands) have been suggested but not quantified.

COST ANALYSIS

There are significant costs associated with the deployment and maintenance of floating islands. Commercial entities offer design, construction, deployment, and maintenance services. Islands require substantial materials and labor for their construction, mooring, and planting. Maintaining, harvesting, and replanting islands can be labor intensive, while removal (which may be necessary seasonally) and redeployment can be costly. Harvested plant materials must also be composted or otherwise removed. Finally, environmental monitoring should be conducted (for example, water clarity, nutrient concentrations, phytoplankton characterizations) to document that the artificial islands are positively affecting water quality and reducing nutrient loads within the water body.

Relative cost per growing season: Floating wetlands

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

REGULATORY AND POLICY CONSIDERATIONS

Permits for deployment of artificial islands vary widely depending on ownership, management, and jurisdiction of the water body. For example, private lakes may require only permission from the homeowner's association, whereas fresh and brackish waters under municipal, state, or federal jurisdiction may involve permitting from the city, county, state, or federal government (for example, USACE).

Public acceptance of this approach stems largely from public perspective on the islands themselves, and that is typically—and often decidedly—mixed. Some residents accept the islands (if they are well designed and deployed), as they provide clear evidence that "something is being done" to address an existing problem. However, aesthetics are important to all users of the water body. Complaints about artificial islands as "eyesores" are not unusual among neighbors and visitors. More significantly, hindrances to boating, water skiing, and other recreational activities are potential detractors for the public.

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