Medora Corporation

Common Sense Suggestions for Lake Restoration Projects

Photographs depicting lake water quality before and after long-distance circulation

Introduction: A lake restoration project should be a rewarding experience, ultimately creating community pride and value for a job well done when the lake's water quality clears up. Lake stakeholders often spend thousands of man-hours over several years discussing the lake's water quality problems and analyzing possible solutions. One or more studies by lake experts may be commissioned, followed by years of arduous efforts to raise money - sometimes millions of dollars - to restore the lake. But, all too often, after the "solution" is implemented the water quality is as poor as ever or else worse. Consequently, many lake groups are facing the same water quality problems today that they worked on years ago, despite spending a lot of time and money in the interim.

Cyanobacteria (also known as blue-green algae) blooms frequently produce up to 90 different types of toxins. These cyanotoxins can kill dogs or people immediately in strong enough concentrations and/or slowly over time if there are lighter but repeated interactions.

Near shore cyanobacteria bloom

Cyanotoxins (similar to mold toxins and other potent bio-toxins) can accumulate in your liver and the problems they cause may not show up until years later. Symptoms years later may resemble paralysis, multiple sclerosis, Parkinson's, or other diseases.

This relatively short paper offers five common-sense suggestions to help lake stakeholders ensure that their lake restoration project is successful the first time. Most of the discussion centers on harmful algal blooms (HABs) as opposed to weed (macrophyte) problems because, while a nuisance, weeds won't kill you like cyanobacteria blooms can.

Suggestion 1: Do not expect nutrient reduction to solve cyanobacteria problems.

Many lake restoration projects focus on reducing the availability of algal nutrients, mainly phosphorus (P) and nitrogen (N), to reduce cyanobacteria blooms. The two main approaches are: 1) to reduce "external loading" of P and N, the nutrients coming into the lake on a regular basis, and 2) to reduce "internal loading" of P by making the P already in the lake unavailable for cyanobacteria blooms.

Regarding "external loading", we strongly support watershed stewardship and protection. However, there is great difficulty in controlling non-point sources of P and N, and only a small amount of nutrients are needed for cyanobacteria blooms. Consequently, watershed management alone of non-point sources has not reversed a cyanobacteria bloom problem in even one single lake in the U.S., even in watersheds where hundreds of millions of dollars have been spent over many decades. It's possible that 50-100 years of watershed stewardship could reverse cyanobacteria blooms in a lake, but most people do not want their lake to be toxic that long.

Regarding "internal loading", P can be released from the sediment at the bottom of the lake, both in deep water where there may be low oxygen during summer stratification and in shallow water if the pH is high due to attached algae or plant growth. The P, which is released from the sediment, can be mixed throughout the upper part of the lake from nightly thermal-driven convective mixing and lateral mixing.

Aeration of deep water and, alternatively, injection of pure oxygen into deep water, has been used to try to oxidize the sediment at the bottom of the lake so that P is not released. But typically the gas bubbles rise toward the surface before they can be spread horizontally in a way that oxidizes all of the sediment. In fact, the rising gas bubbles can make algae blooms worse by transporting P-laden water from the bottom of the lake to the upper part of the lake where cyanobacteria then utilizes the P. The P concentrations in the deep waters may be reduced, but only because P is not accumulating since it is continually being transported upward by the aeration or oxygenation system. Also, neither aeration or oxygenation systems do anything to prevent P from being released in shallow water, due to high pH, and then being transported throughout the lake by nightly thermal-driven lateral mixing. Consequently, there is not a single lake in the U.S. of any size (over 20 acres), to our knowledge, where persistent cyanobacteria problems have been reversed by an aeration or oxygenation system.

Alum (aluminum sulfate) has also been applied to lakes to try to stop internal loading of P. Alum is a heavier- than-water flocculent that pulls P and many other items out of the water as it drifts to the bottom of the lake. In theory, the alum rests on the sediment and permanently ties up all P that came out of the water the day of the application, and all P that was already in the sediment.

There are a small handful of lake experts in the U.S. (5?) that, though they claim to be "neutral" in their lake work, appear to be closely aligned with alum manufacturers and chemical applicators to sell alum to the lake industry. This is presumably due to the large oversight fees available for alum projects. These alum advocates can be counted on to say, for virtually every lake they work on, that in their view "alum offers 10-20 years of water quality improvement". But that long-term effect virtually never happens, and there is no guarantee of even one month of benefits.

Although alum was applied to about 150 lakes in the world between 1970 and 2005, and perhaps another 50 lakes since then, it appears there are less than 5 lakes where benefits of alum may have lasted more than a year or two. A realistic view of alum's effectiveness was presented at a North American Lake Management Society (NALMS) conference in 2005 and involved a follow-up study of alum in Minnesota where alum had been tried extensively over a twenty-year period. That presentation indicated that alum may cause a 1-2 ft. increase in water clarity that can be expected to last from 3 days to 4 years.

Recently the alum advocates have been saying that the reason virtually all alum applications failed through 2000 is that not enough was applied, so "we just need to increase the dosage". But that new philosophy was applied to Green Lake in Seattle, Washington in 2004, a one million dollar alum project for a 260-acre lake, and there were cyanobacteria blooms the very next year, and the milfoil problem got worse. A repeat dose has been discussed. At about the same time, at Mitchell Lake, SD, about $600k of alum was applied over a several year period, and there was no benefit seen at all, not even for a week. And a Finger Lake Research Conference report in December 2009, about the 2006-2007 alum application at Honeoye Lake, NY, states "it is impossible to definitively state that the alum is reducing the internal release of phosphorus". That lake has seen little change in water quality or eutrophic index since the alum application, and in August 2010, one beach was closed due to a large cyanobacteria bloom.

The biggest reason alum does not work is probably that it takes only a little bit of P to cause a cyanobacteria bloom. Alum does not remove any P that enters the lake water the very next day after it's application, such as through new inflow to the lake, or from fish stirring the sediment, or from normal wave disturbance of sediment, or from decomposition of plants and algae and other organic matter in the lake.

Two independent studies by universities in 2005 indicate that another probable reason for alum's general failure may be because the alum releases about half of the P from the sediment back into the water column within 6 months after the application, and most of it within 12 months of the application.

Finally, there are significant risks of aluminum toxicity when alum is applied to a lake. Alum can cause fish kills as it is applied due to adverse respiration effects and benthic toxicity for years after the application. The toxicity issue is being made worse by the heavy doses now being prescribed and that the fact that future doses will also be needed, the only question is "how often?" If a lake that had alum applied ever needs to be dredged, the aluminum toxicity in the sediments could result in a very high cost to dispose of the sediments in an industrial/hazmat landfill, perhaps more than the original cost to apply the alum. For all of these reasons, fortunately, the EPA recently indicated it will be reviewing and possibly tightening the standards for applying alum to lakes.

Alum does seem to offer a benefit in side-stream operations now being used in Florida on the St John's river system and at Lake Apopka. In these applications, the alum-P floc is physically and permanently removed from the water. Sidestream processes are very expensive, and thus not feasible for most lakes and rivers.

In short, at a typical cost of $3,000- $4,000 per acre for each application, alum offers almost no benefit and creates an unjustifiable risk of turning the lake bottom into a toxic soup.

Summarized: A lake restoration program focused only on nutrient reduction, external or internal or both, has less than 1% chance of controlling cyanobacteria blooms based on the experience of thousands of lakes worldwide over the past 50 years. This should not be used as an excuse for allowing poor watershed management; good stewardship of our Earth still requires good watershed management.

Suggestion 2: Constant use of algaecides is not a sustainable lake management strategy.

The most frequently used algaecides are copper-based toxins, which kill cyanobacteria but also beneficial algae, zooplankton and, when the dose is high enough, even fish. Some common species of cyanobacteria can become resistant to the copper, so more and more copper is needed each year. All of this copper eventually ends up at the bottom of the lake, creating sterile and toxic sediment.

Strong oxidants are also sometimes used as algaecides, especially when further buildup of copper toxicity in the lake can no longer be tolerated by the fish or by the court, which has become involved with management of the lake. Examples of such oxidants are hydrogen peroxide (usually in powder form in the U.S.) or potassium permanganate or chlorine. Strong oxidants wipe out not only the cyanobacteria, but also the entire bacterial community in the upper part of the lake, which then releases a flood of nutrients which then fuels a subsequent cyanobacteria bloom a few weeks later.

In short, all algaecides have overly broad lethality, which significantly reduces bio-diversity in the lake. And all algaecides must be constantly applied, as frequently as every week during summer months, in order to prevent constantly recurring harmful algal blooms. The cost for algaecides can easily exceed $1000 or $1500 per acre per year, with the only long-term benefit running to the chemical applicator through the steady income.

Summary: Algaecides can have a useful role for emergency situations, but are far too damaging to the lake and far too costly to be relied on as a long-term solution to lake water quality problems.

Suggestion 3: Study lake circulation equipment; increase your odds for a successful project from less 5% chance of success to over 90%.

There is only one method of controlling algae blooms, developed from 2003 onward, which has consistently controlled cyanobacteria blooms in lakes of all types, and that method is to use long distance solar-powered circulators.

In the spring and early summer, small-celled planktonic algae, usually species of diatoms and "green" algae, dominate most lakes. Planktonic means these algae have no mobility; they just go where the water takes them although, because they are slightly heavier than water, they are always generally slowly sinking. They sink out of the sunlight, which they need for reproduction, if insufficient mixing is present. These algae can also be referred to as "good" algae because they are easily edible by zooplankton of all sizes, and they do not produce taste, odor, toxins or surface scum. Individual cells are not visible to the naked eye but they do impart a tint to the water, brown in the spring when diatoms dominate, or a pleasing green a little later when green algae dominate. These algae absorb P and N very quickly and reproduce quickly, but they never form an unhealthy "bloom" because their population is always controlled by filter-feeding zooplankton, which in turn are eaten by fish, provided the temperature is over 10C so that zooplankton are active. In short, these "good" algae species provide the perfect pathway for the nutrients in the lake to flow up the food chain. The overall result, if these algae dominate the lake all year, is a lake in what is called a "mesotrophic" state, with 6-20 ft. water clarity and large happy well-fed fish, even though there might be a fairly high level of P and N nutrient loading to the lake.

But, in many lakes, by early to mid summer, cyanobacteria become dominant and can take over the lake, potentially producing toxins, odors, and unsightly color and surface scums that negatively affect human use of the lake. Unlike good algae, cyanobacteria are much larger cells and can be visible to the naked eye. They are not planktonic; they can adjust their buoyancy to travel up or down to optimize the gathering of sunlight from the top of the lake or nutrients from the bottom of the lake. And they can clump together to shade out and kill good algae, or to avoid being eaten, and they have many other competitive advantages over good algae. It has been known for a long time that for cyanobacteria blooms to occur, there generally needs to be high levels of nutrients in the water, and stagnant water. Warm water and long sunlight helps them too, but our experience indicates these conditions are not necessary. Once a cyanobacteria bloom takes hold of a lake, in most cases it will take one to three months before the bloom subsides if there is no human intervention.

Circulation of the upper part of the lake (epilimnion) with SolarBee radial-flow solar powered circulators has defeated cyanobacteria blooms in over 400 lakes since 2003, for a success rate of over 90%. 100 of these lakes are drinking water reservoirs with good before-after records. The mixing pattern of SolarBee machines shifts the competitive balance in the lake so that “good” algae, which start sooner in the year and can reproduce much faster than cyanobacteria, dominate the lake all year long. The exact mechanism by which cyanobacteria blooms are defeated by mixing with these machines is probably a combination of several factors:

(a) The good planktonic algae which have sunk 5-10 feet down from the surface, and are at the verge of sinking out of the light and dying, are constantly being pulled into the machine radially from all directions, lifted up to the top of the lake, and then spread out radially across the top of the lake. This takes away the buoyancy-adjusting advantage of cyanobacteria, and probably allows good algae and natural bacteria in the water to out-compete cyanobacteria for available P and N.

(b) The mixing creates a strong ongoing crop of good algae and bacteria in all season that results in more and larger zooplankton which, when they have to in order to survive, will eat cyanobacteria in addition to cropping down the good algae.

(c) When water enters the machine, it is moved up to the surface in a just a few seconds. The sudden reduction in water pressure may cause cyanobacteria (which is constantly adjusting its buoyancy) to pop to the surface of the lake where it dies or is killed by the sun. This effect can also be seen in water samples drawn from 5-10 ft deep and placed into a sample bottle. The cyanobacteria will usually pop up to the top of the water sample bottle in a few hours, and remain there. If this is occurring every day of the year, the cyanobacteria never gets the population traction to create a bloom.

(d) The machine’s mixing pattern may be more effective than wind mixing in distributing cyanophages (viruses of cyanobacteria), and other natural microbial control agents of cyanobacteria, throughout the lake.

It has been known for many years that if water is mixed, such as in most flowing rivers, or in wastewater ponds with surface splashers, cyanobacteria species generally do not become dominant. But most mechanical mixers that have been tried in lakes, and fountains too, have less than 1 acre of effectiveness. Wind and solar powered circulators other than SolarBee brand have had some success in lakes also, but only up to 2-3 acres per machine based on what we have seen. A large SolarBee circulator, on the other hand, can control cyanobacteria for up to 35 acres per machine, and operates entirely off low voltage solar power 24/7/365, every minute of the year, in most lakes. They have a 25 year expected life, high wave kits, factory installation, remote monitoring, are aesthetically pleasing to the eye, and are also far less costly than any other lake restoration method. In most lakes the cost to buy and own SolarBee machines is about $70 to $150 per acre per year, based on the 25-year machine life and depending on lake size, shape, and whether optional factory maintenance contract is purchased. Also, this equipment is portable, requires no infrastructure changes, and the same equipment can be deployed for other purposes too, in a different manner, for projects such as controlling macrophytes, or controlling mercury or iron or manganese problems at the bottom of the lake.

Here is what one customer recently had to say about SolarBees and long-distance circulation: “The SolarBees that we installed in 2006 are still keeping cyanobacteria to a very low level. Typically if we do have a problem, we go out in the field and find that one of the SolarBees has been wind-pushed to shore or is otherwise not working. It is amazing; having the SolarBees working properly makes all the difference in the world for blue-green algae control!” D.H., Iowa

Summary: Using SolarBee equipment to change the manner in which nutrients flow up the food chain has been the only method of consistently restoring lakes to good water quality and eliminating cyanobacteria blooms.

Suggestion 4: Request specific information on where the proposed restoration method has worked in the past.

Although a lake consultant may claim that his/her approach has worked in the past, there are two things you may wish to consider doing.

First, have the consultant or lake manager define exactly what they mean when they say a restoration method “worked.” “Worked” should mean that the cyanobacteria blooms were eliminated. This can easily be demonstrated by water testing of Secchi depth, pH, and oxygen levels during the warm summer months.

Second, ask for a list of lakes where the recommended plan has specifically eliminated cyanobacteria blooms and/or solved the other problems of the lake without the use of toxic chemicals. Then locate and call residents living by those lakes, and ask them about the type of problems they had, the size and depth of their lake, the project details, and whether their observations support the expert’s assessment. Finally, confirm that your lake is sufficiently similar to those lakes to provide confidence that your lake will achieve comparable results. Many of the peer-reviewed papers in this field refer to “successes” which, in fact, have been utter failures.

From our experience since 2003, the only lake experts that have ever managed a project where their recommendation significantly and sustainably improved the water quality in a lake, and without ongoing applications of expensive toxic chemicals, were those who have taken the time to learn about and recommend SolarBee circulators. There are currently over 400 lakes, including over 100 municipal raw water supply reservoirs, benefiting from SolarBee circulation. If requested, we would be very happy to provide all the information and references as recommended in this suggestion.

Summary: It is apt to be extremely expensive if you try to short-circuit the due diligence step. Clearly define expectations, understand ecological consequences, and check numerous references. Expect that many papers by “experts” will call lake projects a “success” when the project was in fact a failure. It’s much better to learn this now than be surprised and disappointed later.

Suggestion 5: Require accountability.

Because virtually all lake projects aimed at solving cyanobacteria blooms fail if they do not involve SolarBee circulation equipment (don’t take our word for this, do your own due diligence!), lake stakeholders would be wise to contractually minimize their financial risk of a failed project.

First, the project’s reasonable expectations and evaluation criteria should be clearly defined. Project evaluation could be tied to a number of different parameters, such as: the reduction or avoidance of toxic algae blooms of the magnitude that would trigger a public safety notice based on World Health Organization guidelines, improvements in water clarity, results of periodic water testing, a lake-user survey of whether the project worked after one year, or other criteria specific to the lake. In many cases, the most analytically useful information will be comparing recorded observations made by people and stakeholders who actually use the lake every day (e.g., home owners, water treatment plant operators, boaters, swimmers, fishermen, etc.) with their reasonable and defined expectations.

Second, stakeholders should require the lake consultant, and/or vendors of equipment or chemicals, to offer either: 1) a money-back guarantee in the event the restoration project is not successful at controlling algae blooms (or whatever problem the lake has) for at least one or two consecutive years, or else 2) a test or rental program, so the effectiveness of the proposed restoration technique can be demonstrated before the purchase is made.

Summarized: Accountability for performance matters in all other fields, lake restoration projects should no longer be an exception.

We hope these suggestions are helpful to you. Please feel free to contact us to discuss your lake water quality problems in greater detail.

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